REVIEW ARTICLE

The integration of Internet of Things (IoT) in precision agriculture

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Precision Agriculture (PA) is a type of agricultural technology that is widely used in the field of agriculture. The Internet of Things (IoT) is one of the most widely used technologies for precision agriculture. However, the application of IoT in precision agriculture has not been fully explored. In this article, a comprehensive review of the current innovative means of utilizing the internet of things in PA practices was carried out. The paper provides a concise review of current applications of the internet and communication technologies in PA. In addition, the paper discusses the design architecture of communicating systems and communication system technologies. The results of the carried-out technical review are as follows: (a) A detailed study of the features of the utilized sensors, agricultural fields and crop changes and the design of communication systems are the key outcomes of the technical review; (b) Using big data for IoT applications in precision farming allows the aggregation and management of a large volume of data captured from a wide variety of different sources; (c) The effective use of big data can have broad and potentially transformative effects for making progress in how to apply IoT for precision agricultural; (d) The current state of the art of integrating Internet of Things (IoT) with precision agriculture is mainly based on the concept of the web of things.

Key Words: *Internet of things; Precision agriculture, Communication system; Web of things*

INTRODUCTION

The integration of the IoT with current applications and future technologies has a noteworthy impact on the economy, society and environment. Consequently, IoT is increasingly found in various sectors and domains, agricultural production being one of its beneficiaries. The current flow of research and development, investment opportunities and the rapid growth of the market highlight the overall potential of smart agricultural solutions. The paper provides a concise review of the current applications of IoT in precision agriculture. We further provide readers with different use case scenarios by describing each step of the research pipeline in precision agriculture, such as monitoring and control including cloud computing, alert systems and other web-based artifacts. We conclude that the IoT has already provided valuable conclusions in the field by performing intelligent data analysis of greenhouses with vertical farming and aeroponics. In the near future, we expect each farmer to take advantage of IoT technology by using some of the agricultural platforms available by connecting their traditional tools and microservices [1,2].

In the field of precision agriculture, the role of scientists and researchers is to increase yield and agricultural management using their knowledge in the field of electronics, software and sensors. PA is an overall term for site-specific crop management, which includes making the right crop input at the right place and the right time, taking into consideration individual field and crop conditions. With a proactive stance to modifying practices to best meet the crop requirements using the available resources and not necessarily maximizing yields, PA contributes to sustainable agricultural development. The design, development and integration of new technologies uniquely customized to the specific conditions of agricultural production make PA a dynamic, interdisciplinary field that uniquely combines biophysical and socioeconomic concepts and methodologies. In present-day agricultural practices, the IoT concept is widely used to achieve a more modern and effective agriculture [3,4].

LITERATURE REVIEW

IoT technologies in precision agriculture

Sensors, networks, Unmanned Aerial Vehicles (UAV), tractors and other smart machines are considered to be the most important elements of the IoT technology-assisted smart farming process. The IoT in smart farming feature of the novel agricultural approach aims for eco-friendly, profitable, productive and well-timed harvests automatically. In this way, it helps the hardware, software and Information Technology (IT) engineering teams as well as farming engineers and agricultural experts to frame smart farming techniques. They also would like to accomplish their smart systems by exploiting their machinery, media server and cloud to monitor farm regions automatically [5,6].

In the agriculture sector, there is a growing demand for the use of technology to enhance production, reduce labor, efficiently utilize resources and decrease adverse environmental impacts. There are several technology solutions deployed for solving agriculture-specific technical problems. A blend of agriculture and technology makes farming smart or intelligent and it is termed as precision agriculture. Precision agriculture involves the use of extensive data about weather, farm conditions and other variables, data acquisition tools, IoT and Artificial Intelligence (AI) software to process this data to monitor and manage crop growth. The goal of precision agriculture research is to define a Decision Support System (DSS) for the entire farm management process so as to optimize returns on inputs while taking into consideration environmental, economic and social sustainability. The integrated use of several smart gadgets and technologies like sensors and actuators, GPS, robotics, AI and IoT with the drones make the system intelligent. The IoT-based setup for precision agriculture is called smart farming [7].

Sensors and actuators: Sensors and actuators are the core of precision farming as the whole idea is based on measurements and management of field variability. There are three main types of sensors applied in precision farming: crop sensors, soil sensors and weather sensors. Crop sensors are utilized for measuring the color and reflectance of leaf vegetation. On the other hand, soil sensors are used for the measurement of soil properties, such as the content of moisture, temperature, texture and salinity. Conversely, weather sensors provide the measurement of environmental data. Additionally, actuators also have a key role in precision farming as they are being used for precision seeding, irrigation and fertilization [8].

Wireless communication technologies: Simple gateway and sensors facilitate load balancing across the system and energy management to extend class battery life. Moreover, this platform is supported with existing cellular infrastructure. It is a national network operator for public-based IoT to provide connection services for IoT devices nationwide. There are various types of Low Power Wide Area Network (LPWAN) technology. They use distinct

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connectivity, bandwidth type, range, service and data transport quality. The diagram offers a low-power long-range communications solution to extend and simplify wireless connectivity for smart cities, smart agriculture and other remote monitoring systems. Sub-1 GHz design centers are attracting great interest. The standard argues to reduce development barriers for suppliers of system-on-chip sensors and gateways, resulting in high compatibility and an extensive selection of diverse communication-informative interest. The performance of traditional sub-1 GHz systems excels in link budget and data rates. However, the excessive link budget is a deterrent because it consumes more power and supports a very short range. The long-range and low-power requirements for IoT devices make these constraints very different. Wireless intelligent networks for sliding window scenarios are used to improve system performance while avoiding overlapping transactions from multiple devices. These are fundamental in large aggregation applications, such as asset tracking, street lighting and condition monitoring [9].

The communication with the devices is more challenging. The devices related to the IoT may involve terrestrial, satellite or hybrid systems. Unlike terrestrial systems, satellite communication can provide resources for a long-range, one-to-many communication model, customized for sparse and remote locations. However, the propagation delay is a key concern for terrestrial devices which require timely interaction such as monitoring and controlling. Many of the supporting technologies and system tools have been progressing over years. Thus, development related to the IoT is inclined with evolution rather than creation. One of the requirements for telemetry in rural and outdoor environments is long-range communications. This kind of communication offers some advantages in different practical activities. LPWAN is a type of wireless network designed for long-range communication with small data streams required by IoT devices.

Data collection and analysis in precision agriculture

The term "actual" refers not only to the timing but also to the precision of the information produced and to the decision support criteria adopted by the decision makers. The online monitoring and the offline data mining are mechanisms strongly linked to each other, which have to be integrated into the information system to provide demonstrations of the current and future state and related research, along with detailed explanations on significant trends. This information is organized in the shape of an active map, providing the evaluated and foreseen status of an activity before during and after the occurrence at different resolution scales.

Precision agriculture is divided into three management levels. Management level 1 deals with the activities aiming to describe the state of the cultivated plants or observed characteristics of samples. All relevant characteristics or parameters describing the physical condition are collected and can then be used to verify the supposed plant behavior according to the models or reference conditions. This data can be exploited by real-time centers, which adjust any actions, e.g. operating parameters for the agricultural machines, fertilizers and plant protective agents to the actual requirements and therefore optimize the process. They are designed to evaluate an actual situation but also the future development of a given activity, irrespective of it being related to the control of machines and procedures or to the forecast of plant and animal conditions at different scales.

Remote sensing technologies: Trimble GreenSeeker is a passive sensor that provides real-time yield estimates. The optical sensor is suspended directly over the row crop to be monitored. Light output is used to determine uniformity for a single row, and crop density is recorded in overall uniformity. The Global Positioning System (GPS) signal is used to determine the speed of travel while the sensor is activated. Data is computed and displayed in a map chart with the GPS data. The GreenSeeker operates down to three inches above the canopy of row crops such as cotton, corn, sugarcane and wheat. Grazing research has used a GreenSeeker monitor to establish and compare the overall relative forage quantity of grazed and ungrazed ranges.

CropScan is a passive crop-infrared sensor that measures the amount of light reflected by the leaves, then converts it to a Leaf Area Index (LAI) measurement. The LAI measurements can be used to control ripening and check the overall plant health. The reflectance-based measurements are obtained in the near-infrared and visible spectrums. CropCircle is also a passive sensor tool that can calculate the leaf area index of a crop stand. It measures red and near-infrared reflectance at four spectral bands to derive the LAI measurements [10].

Remote sensing technologies have an important role in precision agriculture as they direct the use of resources according to the variability in the field. The images, taken by sensors, show the spatial variability of the factors affecting crop yield and give farmers the necessary spatial information for decision-making. It is a low-cost solution to provide timely status. There are two types of remote sensing: Passive sensors and active sensors. Passive sensors measure the solar radiation reflected or emitted by objects.

Big data analytics: The whole basis for IoT is to connect everyday devices to a network with the ability to send and receive data. Most people are considering mundane things like watches, washing machines, dishwashers and the like but the same hypothesis can also be applied to fields of crops, irrigation equipment, soil nutrients, weather, crop pests, crop diseases and humidity. Furthermore, interconnections can also be made to crop forecasting, transportation, weather forecasting, energy usage, mobile operations and many others. This is where the connected environment is going. Smart agricultural industries embedded software into the controllers that do everything from monitor soil weight to provide the perfect environment for root growth and associated needs. This is picture recognition and logistics of the highest level.

This refers to large amounts of data from precision agriculture, which can come from various sources such as satellites, GPS and mapping systems, sensors and telematics, environmental factors such as weather forecasts or historical weather data and wide expertise from service/equipment providers, growers, toxicologists, entomologists and plant pathologists etc. Often, data is multilayered and can be very complex. Big data analytics are crucial to this topic mainly in the following areas of scientific research for generating new ideas, knowledge discovery, finding innovative patterns and building decision support systems. Crop modelling decision support, pest management, decision support, decision support for irrigation and soil management, yield variability and decision support have all taken or are taking advantage of big data for forwarding enhanced solutions.

IoT applications in crop monitoring and management

One of the principal areas that can leverage the use of IoT is precision agriculture. Precision agriculture is an agro-industrial management model where producers can identify in the field, monitor and apply crop inputs in real time for improved productivity. Among the products that this technology can supply are reduced use of chemical inputs such as pesticides, improved control over irrigation applied to land and greenhouse products, soil evaluation with consequent application of nutrients, reduction of physical damage in post-harvest, higher productivity and improved early prediction of crop productions, which optimizes logistics of storage and transport. The benefits of implementing precision agriculture for producers can include improving the quantity and consistency of products, optimizing the application of inputs, reducing environmental impact, respecting the existing legislation and thus mitigating risks, making economic and efficient decisions [7,11].

By generating pertinent agricultural information from a variety of resources (sensors, drones, satellites, georeferenced reports, among others) within a complex and dynamic reality, data analysis can be simplified. Moreover, the possible interactions of this collected data can contribute to agricultural control and management by reducing the ecological and economic threats on crop production. Advances in information and communication technologies have contributed strongly to the creation of the term Internet of Things (IoT), a set of physical objects that can exchange information and messages *via* the internet. The IoT is portrayed by systems connecting devices and objects that are uniquely identifiable on the network.

Soil moisture monitoring: There is a library of countless papers detailing the great number of soil moisture measuring devices enhancing precision agriculture. The importance of this figure lies in the fields in the research area, showing that engineers have to pay much more attention to R4, i.e., correct device utilization. The amount of water in the soil is presented in a large range, besides technological area better than a half a century available for artificial (irrigation) support to the plants. The amount of water determines the chemical and biological reactions as well. Large portions of the Earth are semi-arid or arid lands and areas with scarcity of water belonging to 70% of the world's population are widespread. These two key figures highlight the fact that the importance and the attention of managing water does not stop at the "normal" agricultural lands but should be definitely and attentively

considered in large areas of the World. On the other hand, in humidity areas, water might be toxic as well if present in very high excess. Satisfying the requirements of the plants is not a simple task at all.

We detailed the importance of soil moisture to the crop and how it is traditionally and in modern agriculture monitored. Then, we discussed the technology choices of soil monitoring in precision agriculture in the light of soil's electrical characteristics using five different future scenarios for in-field soil moisture monitoring. The great importance of soil moisture for plants is widely known. Soil moisture, described in percentage or volume units and measured by the volumetric is the most critical environmental parameter for most plant species. The plant itself causes several processes within the plant for example, photosynthesis and nutrient transportation. If it is not present at the distance required by the crop, one of the immobile nutrients can become limiting. Plants have no possibility of getting the needed moisture. The closeness of the water within the plant fluctuating around 95%. Due to rapid moisture loss, plants can collapse in a very short period under unfavorable, for example, dry and hot, conditions [11].

Pest and disease detection: Currently, pest and disease detection is primarily based on the scouting methodology, where trained agricultural personnel move throughout the plants, visually checking for diseases and pests at a set frequency, depth and method. This traditional physical methodology creates problems such as high work costs, pathogen transmission between plants or other fields, inaccuracy, inconsistency and delay in detection. In line with this, biological methods have been developed, based on the deployment of beneficial insects on a set frequency, but their success is highly dependent on the density and type of beneficial insects in the field. Early detection is the key in both cases. This is the focus of hypsometric plant sensing. However, there are a few pests and diseases for which remote sensing is difficult, such as the apple maggot. In line with that, pest modeling includes pest life stage models, which use biological sub-models that predict the stage of the pest based on initial pest life-stage inputs. Typically, the proximal inputs to these models are thermal sums, measured in degree days based on daily mean temperatures in the environment. More recently, these pest models have been applied in IoT-based precision agriculture systems to assist farmers in deciding which time is most opportune to apply commercial pheromones and matrics, e.g. the entomopathogenic fungus *Metarhizium brunneum*, in the case of *Drosophila suzukii* pest control [12,13].

Pest and disease detection is one of the categories with the highest potential benefits of the implementation of internet of things sensors in precision agriculture. This category is highly relevant for the European Union (EU), where the reduction in the quantity of Crop Protection Agents (CPAs) as well as the partial replacement of existing CPAs are important issues and are defended in the 2020 European Green Deal. Pest and disease detection is directly related to reducing the use of CPAs, by automatically detecting the first stages and triggering the deployment of beneficial insects or other methods for controlling these issues without using CPAs. In addition, rapid and automatic detection is also related to early disease or pest control with CPAs, which normally requires resolved symptoms.

IoT applications in livestock monitoring

In the last few years, many studies have shown that the precision of animal production can be improved by the use of IoT technologies. The main argument in livestock management is to bring the right tools for support in critical decisions regarding farm management in all areas, enabling animals to express their maximum genetic potential, ensuring animal welfare and increasing the sustainability of the production system. By monitoring animals individually (e.g. feeding, reproduction and health), an increase in efficiency of farms is expected. The requests for products derived from livestock are increasingly specific, so precision supplementation is indispensable. The forage availability measurement is also significant for ranchers who carry out rotational management. Within this branch of IoT, there is a technological trend that uses "sensors to talk to plants". Water is also an important factor to consider in the management of livestock. Scientists have defined different ways to monitor water stress. In addition, it is necessary to reinforce that excessive water supply is as dangerous as insufficiency. Dairy cows and bulls remember the seasonal quality of food, so the availability of grass throughout the year must be guaranteed.

DISCUSSION

Challenges and opportunities in implementing IoT in precision agriculture

It is important for professional scientists to integrate a large number of things in precision agriculture to shape our future of smart farming. In an engineering point of view, this means establishing highly integrated and intelligent communication and sensory systems in agricultural fields, to achieve more focused and quantitative data than human-based observations. The proliferation of precision agriculture brings together the concept of the Internet of Things (IoT) and agriculture, specifically for information delivery, analysis and support for precision agriculture technologies. The technical research costs for most agricultural studies related to IoT also seldomly meet the sophisticated demands of agricultural researchers. The opinions of how IoT may contribute to precision agriculture also vary. Important scientific challenges arise from combining different types of sensory data over time and using it to provide advice to a farmer in an operational setting. The first question that should be asked in this context is what is the environment, specifically agriculture, that an IoT for agglomerating various sensing items involves. This question requires more than a look at the enabling technologies.

Precision agriculture requires the acquisition of data with various sensing technologies. To fulfill the need for more specific data, the number of sensors is extended through the principles of IoT to form Internet of Things specific to Agriculture (IoTA). In this article, a detailed review of current state-of-the-art means of utilizing IoT in PA practices was carried out. An investigation into the features of the utilized sensors, agricultural fields and crop changes, the design architecture of communicating systems and communication system technologies are the key outcomes of the carried-out technical review. Although those are not all that is needed to integrate IoT in PA practices, eight steps, in the format of a flowchart, were developed to guide professional scientists working on implementing IoT in PA practices. According to the carried-out review, these steps should be tailored considering PA demands and the available resources. The identification of not only the communication systems encompassing IoT sensors, but also transmitting transmitted data, is required for PA applications to be improved.

Data security and privacy concerns: In large-scale precision agriculture practices, several agricultural sensors need to be cascaded and deployed on farmland and these sensors can communicate wirelessly to form the edge network of a large-scale precision agriculture internet of things system with agricultural production equipment for field *in-situ* monitoring and the collected data is transmitted to the decision-support expert agricultural management system through base stations or gateways. The IoT system aggregates the rich, real-time data of the remote planning and execution processes in the extended edge network and connects service procedures for direct or indirect interoperability *via* a back-end service procedure bus to support high-level decision making, high-quality mission operation and personalized, proactive agricultural management.

In agricultural practice, a variety of new technologies have been a breakthrough and the application of precision agriculture has achieved remarkable results. The continuous evolution of the IoT has also made our lives full of wisdom, but during the integration of the internet of things in the application of precision agriculture, we also need to pay attention to data security and privacy protection. This paper mainly integrates low-latency, low-power and low-cost wireless communication technology for energy-constrained devices such as sensors and actuators. We build long-range, large-scale IoT systems to meet the needs of large-scale data collection and data interactions in precision agriculture.

Interoperability issues: The intertwining of ubiquity, intelligence and connectivity, which are enabled by wireless sensor networks, embedded systems and Internet technologies, is the key point to create the IoT. Effectively, small-scale households or individuals can build sensor networks to enable the connection to everyday objects. However, most sensor nodes are involved in sensor network activities to achieve a specific goal, without sharing their sensing data with other users. The services to be developed are strictly dependent on the sensors and their locations, which in culturally different locations, population densities and pacing, leads to services that waste infrastructure, power and invaluable time. It is, in fact, a complicating

IoT issue. Interoperability in the IoT context means enabling the interaction and cooperation of heterogeneous devices and services in a transparent or invisible way, in such a manner that the user is unaware of their presence. It is a key concept for creating an open working environment for devices and services in the IoT, allowing the development of advanced applications with new and rich functionalities previously unimagined. In particular, interoperability issues of IoT devices employed in precision agriculture can be identified as either technological myths about IoT being solved or current problems-situations that are real, but the technology is currently dealing with.

Future trends and innovations in IoT for precision agriculture

Using big data applications in IoT-assisted precision agriculture allows the aggregation and management of a large volume of data types captured from a wide variety of different sources. The effective use of big data for IoT applications in precision agriculture will involve improvements in information technology and communication technology to manage the capture and sharing at appropriate spatial granularity, cost and scale. Appropriately structured data sets can guide smart data analytics to provide direction and decision assistance for its sensor informatics users. Common access to these data can also have economic benefits, such as better risk-based pricing that insurance companies can apply to provide their growing market for agricultural weather insurance. The effective use of big data can have broad and potentially transformative effects for making progress in how to apply IoT in precision agriculture. Smart data capture and sharing can enable savings over the entire food production and processing chain. The early identification of supply and demand imbalances can enable price smoothing over regular and irregular fluctuations in market conditions. In the long run, participants in the food production and processing chain can benefit from forward contracts that reduce the risk for their primary product pricing changes under volatile market conditions [14,15].

Future direction of IoT for precision agriculture involves adapting IoT for precision agriculture, using big data to guide IoT applications and adopting interlinked governance for resolving concerns raised with the implementation of IoT for precision agriculture. Agriculturists are the most affected stakeholders by the adoption and use of IoT for precision agriculture applications. They are also the ones who use and generate the data that enable the development of related applications. To achieve integration and formulation with IoT applications and precision agriculture has the potential to change the consumer-to-farmer relationship in a way that places agricultural producers at the center of an agri-food innovation system. This will require improved information flow and coordination, establishing a feedback loop [16].

CONCLUSION

In conclusion, the integration of internet of things with precision agriculture is transforming agricultural practices by enhancing data collection and analysis, leading to more efficient and sustainable farming. The review highlights how IoT technologies, including sensors and big data analytics are instrumental in optimizing crop and livestock management, improving resource use and reducing environmental impact. Despite advancements, challenges such as data security, interoperability and the need for effective communication systems remain. Future innovations are expected to refine these technologies further, making precision agriculture more accessible and impactful. Ultimately, internet of things role in precision agriculture promises significant improvements in agricultural productivity and sustainability.

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RESEARCH ARTICLE

Integrated disease management of sclerotinia rot of chickpea (*Cicer arietinum*) incited by *Sclerotinia sclerotiorum* (Lib.) de Bary

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Kumar V. Integrated disease management of sclerotinia rot of chickpea (*Cicer arietinum*) incited by *Sclerotinia sclerotiorum* (Lib.) de Bary. AGBIR.2024;40(5):1318-1321.

Chickpea is an annual legume crop grown in temperate and subtropical regions. It belongs to the Fabaceae family and is native to Southwest Asia. Chickpea have been cultivated since ancient times in both Asia and Europe. India stands as the largest producer and consumer of chickpea globally, contributing roughly 75% of the world's total production. It is primarily consumed in various processed forms, such as boiled, roasted, fried or steamed whole seeds as well as in the form of dal and dal flour. They are commonly used in the preparation of snacks, sweets and condiments. Chickpea crop is prone to various diseases like, dry root rot (*Rhizoctonia bataticola*), Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*), wet root rot (*Rhizoctonia solani*), collar rot (*Sclerotium rolfsii*), Aschochyta blight and Sclerotinia rot (*Sclerotinia sclerotiorum* (Lib.) de Bary). Among various diseases, Sclerotinia rot, also known as stem rot, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, is one of the most significant. It causes substantial yield losses, especially in cool and moist areas conducive to its development. The fungus's explosive pathogenicity and the resilience of its sclerotia contribute to its success as a pathogen. Due to its strict soil-borne nature and wide host range, managing this disease through host resistance or chemical management alone is challenging. Fungicides are commonly used to control plant diseases, but they pose environmental and health risks and can lead to environmental hazards. Therefore, integrated disease management using both bio-agents and fungicides is the best alternative. The results showed that Sclerotinia rot incidence in chickpeas was significantly reduced and yield increased when chemical and biocontrol agents were used together, compared to using either chemicals alone or biocontrol agents alone. Among the different treatments, the highest percent of disease control (81.40%) was found in T_{12}-Seed Treatment (ST) with tebuconazole 2% DS at 1.5 g/kg seed+Soil Application (SA) at 10 kg/ha with *Trichoderma harzianum*, followed by T_{11}-ST with tebuconazole 2% DS at 1.5 g/kg seed+SA at 10 kg/ha with *Trichoderma viride* (80.33%). The highest disease incidence was found in T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed (37.77%).

Key Words: *Biocontrol agents; Chickpea; Fungicides; Integrated disease management; Sclerotinia rot*

INTRODUCTION

Cicer arietinum, commonly known as chickpea, is an annual crop that grows in temperate and subtropical zones and is native to Southwest Asia. It is also called by various names such as gram, Bengal gram, garbanzo, garbanzo bean, Egyptian pea, chana and chole in various places. Pulses are the important source of protein in the diets of the poor and are particularly important in vegetarian diets. It is cultivated from ancient times both in Asia and European countries. India is the largest producer and consumer of chana in the world. India accounts approximately 75% of world's chickpea production. Mainly there are two types of varieties of gram desi and kabuli. Approximately 80% of the chana produced in world is of Desi type and the remaining is of kabuli variety. In India, Desi variety is also cultivated massively.

It is mainly consumed in the form of processed complete seed (boiled, roasted, fried, steamed, etc.), dal and as dal flour. It is used in preparing snacks, sweets and condiments. Fresh green seeds are also used as a green vegetable. It is an excellent source of protein (20.47%), carbohydrates (62.95%), fat (6.04%), minerals (calcium, phosphorus, iron etc.) and vitamins [1]. It is a superior animal feed and the straw of gram also have good or satisfactory forage value [2]. Due to the presence of malic and oxalic acid, the leaves of chickpea have sour taste. Malic and oxalic acids collected from green leaves of are prescribed for intestinal disorders. Chickpea is used as blood purifier and germinated seeds are recommended to cure scurvy disease.

Chickpea is cultivated in 25 states of India, Rajasthan is one of the major chickpea growing states of India after Madhya Pradesh and Maharashtra. In Rajasthan the major chickpea growing districts are Ajmer, Bikaner, Hanumangarh, Pali, Tonk, Bhilwara, Jaisalmer, Nagaur and Jaipur etc. In India, it occupies an area of 10 million hectares and its production is 11.91 million tons with an average productivity of 1192 kg ha-1. In Rajasthan, it is grown over 2.11 million hectares area with annual production and productivity of 2.27 million tons and 1072 kg ha-1, respectively. Unfortunately, the productivity of chickpea is not at the level of satisfaction i.e., average global productivity of 1800 kg ha-1 and it remains plateau since independence of India [3].

Nearly 172 pathogens (67 fungi, 22 viruses, 3 bacteria, 80 nematodes and phytoplasma) will cause diseases in chickpea [4]. These pathogens may be of bacteria, mycoplasma, fungi, nematodes and viruses which contain high genotypic variation. Among various biotic factors attributed to low productivity of chickpea, susceptibility to diseases is very important. Chickpea is susceptible to different diseases including, Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*), dry root rot (*Rhizoctonia bataticola*), wet root rot (*Rhizoctonia solani*), collar rot (*Sclerotium rolfsii*), Ascochyta blight and Sclerotinia rot (*Sclerotinia sclerotiorum* (Lib.) de Bary) [5]. These diseases have been found to cause considerable economic losses to the chickpea growers in India [6]. The extent of losses from 20% to 46% at pod bearing stage of the crop and the incidence of disease varied from 18% to 32% [7].

Amongst different diseases, Sclerotinia rot commonly called as stem rot or white mold caused by *Sclerotinia sclerotiorum* (Lib.) de Bary is one of the most important disease. The detonative pathogenicity under favorable conditions and the ability of producing sclerotia to withstand adverse conditions allow it to be a successful pathogen [8,9]. It causes significant yield losses whenever, the crop is grown in relatively cool and moist areas favorable for its development [7]. The disease causes total crop failure where chickpea is grown in the same paddock in successive years. Dense crops are likely to be the most severely affected, particularly, under moist condition. This disease has been reported from different parts of India and causing considerable losses [10]. The extent of the damage was reported from 21.3% to 46.7% at pod bearing stage of the crop [11]. In Jammu and Kashmir, the disease incidence varied from 18.7% to 32.2%. The recent observations suggested that the incidence and severity of Sclerotinia rot of chickpea is increasing in the Northern part of India. In Rajasthan, stem rot (*S. sclerotiorum*) was

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initially observed at Agricultural Research Station, Umedganj, Kota in the year 1993-1994 and thereafter, it has been appearing regularly in mild to severe form in various parts of the state [12].

MATERIALS AND METHODS

The fungicides are the most common tools for controlling plant disease. But they are not feasible for environment, health and it leads to environment hazard. Hence integrated management of the disease by using bio-agents and fungicides is the best alternative [13,14]. Therefore, it is an urgent need to use some bio-agents and fungicides which are effective against Sclerotinia rot disease. Hence, keeping in view the importance of chickpea crop and potential threat of *Sclerotinia sclerotiorum* in all the chickpea growing areas in the Rajasthan, the present investigation was undertaken to manage of this important disease through bio-agents and fungicides.

A field trial was conducted for the management of Sclerotinia rot of chickpea using bioagents and fungicides in rabi season. Talc based formulations of two fungal and two bacterial bioagent were applied as seed treatment and soil application and fungicides were used as seed treatment. Seed treatment of fungicides and seed and soil treatment of the talc based bioagent formulations was done. In case of control, seeds were sown in pathogen inoculated soil without any bioagents and fungicides. Observations were taken periodically for the disease incidence.

Total 13 treatments including control were carried out using randomized block design having plot size of 4 × 4 m2. Each treatment was replicated thrice. The experiment was conducted under artificial soil inoculated conditions. For this purpose, sand sorghum meal inoculum of *Sclerotinia sclerotiorum* was applied at 70 g per plot and mixed properly on top surface soil using a hand rack. Standard agronomic practices recommended for cultivation of chickpea crop in this region were followed. In case of control, the untreated seeds were sown. Observations on disease incidence were recorded periodically as well as the grain yield was recorded after harvesting of the crop.

Incidence of the disease and percent disease control was calculated by using the following formula [15];

$$Disease\,incidence\ (\%) = \frac{No.\ of\ diseased\ plants}{Total\ No.\ of\ plants\ germinated} \times 100$$

$$Disease\ control\ (\%) = \frac{Disease\ incidence\ in\ control\ (\%) - Disease\ incidence\ in\ treatment\ (\%)}{Disease\ incidence\ in\ control\ (\%)} \times 100$$

The data of percent disease incidence in all the experiments were transformed to their arc sin values [16]. The statistical analysis of the data of all the laboratory experiments was done following completely randomized design. The data of field experiments were analyzed following randomized block design.

RESULTS AND DISCUSSION

The results in Tables 1 and 2, show that Sclerotinia rot incidence in chickpeas was significantly reduced and yield increased when chemical and biocontrol agents were used together, compared to using either chemicals alone or biocontrol agents alone. Among the different treatments, the highest percent of disease control (81.40%) was found in T_{12}-seed treatment with tebuconazole 2% DS at 1.5 g/kg seed+soil application at 10 kg/ha with *Trichoderma harzianum* followed by T_{11}-ST with tebuconazole 2% DS at 1.5 g/kg seed+SA at 10 kg/ha with *Trichoderma viride* (80.33%), T_{10}-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed+SA at 10 kg/ha with *Trichoderma harzianum* (78.89%) and T_9-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed+SA at 10 kg/ha with *Trichoderma viride* (77.45%) as compared to control where 62.37 percent disease incidence was recorded. The highest disease incidence was found in T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed (37.77%), followed by T_4-ST at 10 g/kg+SA at 10 kg/ha with *Bacillus subtilis* (34.67%) and T_3-ST at 10 g/kg+SA at 10 kg/ha with *Pseudomonas fluorescens* (32.50%). The results revealed that all twelve treatments, including single fungicides and their combinations with biocontrol agents, were superior to the control in reducing disease incidence and increasing seed yield of chickpea (Figure 1).

TABLE 1

Management of Sclerotinia rot of chickpea by bioagents and fungicides

Treatments	Disease incidence (%)*	Disease control (%)
T_1-ST at 10 g/kg+SA at 10 kg/ha with *T. viride*	21.33 (27.42)	65.79
T_2-ST at 10 g/kg+SA at 10 kg/ha with *T. harzianum*	20.27 (26.70)	67.5
T_3-ST at 10 g/kg+SA at 10 kg/ha with *P. fluroescens*	32.50 (34.73)	47.89
T_4-ST at 10 g/kg+SA at 10 kg/ha with *B. subtilis*	34.67 (36.04)	44.41
T_5-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed	26.37 (30.87)	57.72
T_6-ST with tebuconazole 2% DS at 1.5 g/kg seed	24.23 (29.46)	61.14
T_7-ST with tebuconazole 50%+trifloxystrobin 25% WG at 1.5 g/kg seed	27.73 (31.74)	55.53
T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed	37.77 (37.89)	39.44
T_9-T_5+SA at 10 kg/ha with *T. viride*	14.07 (21.98)	77.45
T_{10}-T_5+SA at 10 kg/ha with *T. harzianum*	13.17 (21.23)	78.89
T_{11}-T_6+SA at 10 kg/ha with *T. viride*	12.27 (20.46)	80.33
T_{12}-T_6+SA at 10 kg/ha with *T. harzianum*	11.60 (19.79)	81.4
Control	62.37 (52.15)	0
S.Em±	1.66	67.00%
CD at 0.05	4.87	67.00%
CV (%)	11.04	67.00%

Note: ST: Seed Treatment; SA: Soil Application; WP: Wettable Powder; WG: Water-Dispersible Granule; DS: Dustable Sulfur; S.Em: Standard Error of the mean; CD: Critical Difference; CV: Coefficient of Variation.

TABLE 2

Effect of bioagents and fungicides on the yield of chickpea

Treatments	Yield (q ha-1)*	Yield increase over control (%)
T_1-ST at 10g/kg+SA at 10 kg/ha with *T. viride*	12.03 (20.22)	124.22
T_2-ST at 10g/kg+SA at 10 kg/ha with *T. harzianum*	12.83 (20.93)	139.13
T_3-ST at 10g/kg+SA at 10 kg/ha with *P. fluroescens*	8.90 (17.25)	65.84
T_4-ST at 10g/kg+SA at 10 kg/ha with *B. subtilis*	7.93 (16.16)	47.83

T_5-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed	10.43 (18.69)	94.41
T_6-ST with tebuconazole 2% DS at 1.5 g/kg seed	11.17 (19.41)	108.07
T_7-ST with tebuconazole 50%+trifloxystrobin 25% WG at 1.5 g/kg seed	9.70 (18.03)	80.75
T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed	7.13 (15.33)	32.92
T_9-T_5+SA at 10 kg/ha with *T. viride*	14.47 (22.28)	169.57
T_{10}-T_5+SA at 10 kg/ha with *T. harzianum*	15.37 (23.01)	186.34
T_{11}-T_6+SA at 10 kg/ha with *T. viride*	16.07 (23.57)	199.38
T_{12}-T_6+SA at 10 kg/ha with *T. harzianum*	16.90 (24.20)	214.91
Control	5.37 (13.14)	0
S.Em±	1.24	CV (%)
CD at 0.05	3.65	CV (%)
CV (%)	11.11	CV (%)

Note: ST: Seed Treatment; SA: Soil Application; WP: Wettable Powder; WG: Water-Dispersible Granule; DS: Dustable Sulfur; S.Em: Standard Error of the mean; CD: Critical Difference; CV: Coefficient of Variation.

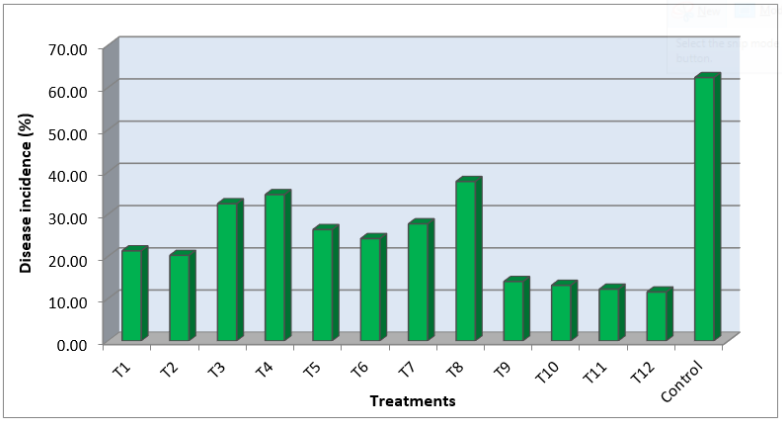


Figure 1) *Effect of bioagents and fungicides on Sclerotinia rot disease incidence of chickpea*

Similarly, Pandey et al., found that applying vermicompost at 5.0 tons/ha combined with *T. harzianum* at 5.0 kg/ha was the most effective treatment, reducing disease incidence by 72.73% and increasing grain yield by 39.69% [17]. This was followed by Farmyard Manure (FYM) at 2.5 tons/ha combined with *T. harzianum* at 5.0 kg/ha, which resulted in a 64.85% reduction in disease incidence and a 38.17% increase in grain yield. The least reduction in disease incidence (14.55%) and the smallest increase in grain yield (15.27%) were observed with foliar spray of P. fluorescens at 5.0 g/liter. Mandal et al., reported that seed treatment with Pusa 5SD (*T. viride*) combined with carboxin and *Mesorhizobium ciceri*, along with a foliar spray of iprodion 40 days after sowing, provided the highest disease reduction and improved plant health parameters such as seed germination, shoot and root lengths and the number of pods per plant [10]. While Pusa Biopellet 4G and Pusa 5SD individually were effective in reducing disease incidence and enhancing plant health, their combined application was superior to using any of these formulations alone. Sharma et al., evaluated six different fungicides against *S. sclerotiorum* under *in vitro* conditions and tested their efficacy in controlling Sclerotinia rot in pot conditions [18-20]. Carbendazim and the consortium formulation of carbendazim 12%+mancozeb 63% were significantly superior to the other fungicides in inhibiting the mycelial growth of the pathogen and controlling Sclerotinia rot, achieving 100% growth inhibition at a lower concentration (50 ppm) and 73.94% and 67.57% control of rot incidence when applied as a seed treatment (2 g/kg) and foliar spray (0.1% and 0.2% solution), respectively. Propiconazole was the next most effective, providing 67.41% inhibition of growth at the lowest concentration (50 ppm) and 61.21% protection against rot incidence when applied as a seed treatment (2 ml/kg) and foliar spray (0.1%).

CONCLUSION

Chickpea is an annual legume crop legume crop cultivated in temperate and subtropical regions. It is a member of the Fabaceae family. Among various diseases, Sclerotinia rot, also known as stem rot or white mold, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, is one of the most significant. This disease is highly pathogenic under favorable conditions and produces sclerotia that can endure adverse conditions, making it a highly successful pathogen. It causes substantial yield losses, especially in cool and moist areas conducive to its development. The fungus's explosive pathogenicity and the resilience of its sclerotia contribute to its success as a pathogen. Due to its strict soil-borne nature and wide host range, managing this disease through host resistance or chemical management alone is challenging. Fungicides are commonly used to control plant diseases, but they pose environmental and health risks and can lead to environmental hazards. Therefore, integrated disease management using both bio-agents and fungicides is the best alternative.

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REVIEW ARTICLE

Use of biofertilizers in modern agriculture

Lalita Verma[1], Vijay Kumar[2*]

Verma L, Kumar V. Use of biofertilizers in modern agriculture. AGBIR.2024;40(4):1191-1193.

The fertilizer production in our country is less than the required amount. To fill this gap, alternate sources of nutrients have to be looked for. Organic wastes and biofertilizers are the alternate sources to meet the nutrient requirement of crops and mitigating nutrient deficiencies. Further, knowing the harmful effect of using only the chemical fertilizers on soil health, use of chemical fertilizer along with compost and biofertilizers is required which will help to maintain soil health and productivity. With the introduction of green revolution technologies, the modern agriculture is getting more and more dependent upon the steady supply of synthetic inputs (mainly fertilizers). Adverse effects are being noticed due to the excessive and imbalanced use of these synthetic inputs. This situation leads to identifying harmless inputs like biofertilizers whom use in crop cultivation will help in safeguarding the soil health and also the quality of crop products.

Key Words: *Biofertilizers; Rhizobiu; Phosphate solubilizing bacteria; Potassium mobilizing bacteria; Silicon solubilizing bacteria*

INTRODUCTION

Biofertilizers are the products containing one or more species of microorganisms which have the capacity to mobilize nutritionally important elements from non-usable to usable form through biological processes such as nitrogen fixation, phosphate solubilization, excretion of plant growth promoting substances or cellulose and lignin biodegradation in soil, compost and other environments. These microorganisms, which may include bacteria, fungi or algae, carry out a variety of biological processes that are significant for enhancing soil fertility and plant growth. One of the most significant advantages of biofertilizers is that they are completely harmless to the environment. Unlike chemical fertilizers, which can cause pollution and long-term soil degradation, biofertilizers are natural, non-toxic and sustainable. They contribute to a reduction in the need for synthetic fertilizers, which in turn lowers the risk of groundwater contamination, soil acidification and the depletion of essential soil microorganisms. Moreover, biofertilizers are low-cost renewable agricultural inputs. By improving the availability of nutrients in the soil, biofertilizers support healthier plant growth, higher crop yields and better-quality produce. They play a significant role in improving nutrient availability in plants. They are recognized as a components of integrated plant nutrient supply system [1].

A crop nutrient management plan is a tool that can increase the efficiency of all the nutrient. Nitrogen promotes the vegetative growth and increase protein content in the crop. Phosphorus enhances the activity of rhizobia, increase the formation of root nodules, stimulates early root development, helps in fixing more atmospheric nitrogen and aids in grain formation when applied to legumes. It also improves the crop quality and resistance to disease. Potassium also plays a major role in the transport of water and nutrients for whole of the plant in the xylem. In general, sulphur is required for the synthesis of vitamins and promotes nodulation in legumes. Sulphur is known to play an inevitable and imperative role in sulphur containing amino acids i.e., cysteine, cystine and methionine, vitamin and protein synthesis. The need of nitrogen, phosphorus, potassium and sulphur are determined by the crop [2]. Biofertilizers help in the maintenance or adjustment of plant nutrient supply to an optimum level for sustaining desired crop productivity and soil fertility.

In sandy soils of semi-arid regions, drought stress and lack of nutrients (mainly nitrogen and phosphorus) are considered as the main production constraints. Therefore, guar is expected to fit very well in this region as an important drought tolerant cash crop and soil-building crop, with respect to available nitrogen through nitrogen fixation to maintain soil fertility and sustainable productivity [3].

LITERATURE REVIEW

Liquid biofertilizers are liquid formulations have the dormant form of desirable micro-organisms and their nutrients together with the substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to unfavorable conditions. The dormant form of reaching the soil, germinate to create the fresh batch of active cells. These cells developed and multiply by utilizing the carbon source in the soil or from root exudates. A lot of work done on carrier-based biofertilizers in the context of organic food production. In view of the advantages of liquid biofertilizers over carrier based formulations, research has now been started on the production and testing of liquid biofertilizers. Consequently, liquid biofertilizers are specifically formulated solution that contains beneficial micro-organism which improves nutrient uptake by converting it in soluble form, increase soil fertility, produces plant growth promoting substances and plant hormones thereby reduces chemical fertilizer usage up to 20%-30% [4]. Fungi, bacteria and *Cyanobacteria* are the main source of bioferlizers. Fungi are non-green microorganisms; aside from making phosphorus available in the soil for plant uptake, they help to aggregate the soil structure. *Cyanobacteria* are symbiotically associated with *Azolla* and also known as blue-green algae. Species of blue green algae are Nostoc and *Anabaena*. Examples of fungal biofertilizers are *Mycorrhiza*, *Fusarium* species and *Penicillum* species. Examples of bacterial biofertilizers are *Azotobacter*, *Azospirillum*, *Clostridium*, *Rhizobium* etc. A combination of biological and chemical sources of nitrogen are cheaper and impressive way of increasing production under limited resources [5]. Biofertlizers are applied as grain treatment or applied in the soil. Biofertilizers in liquid formulation are easy to handle and applied at 3-5 ml/kg grain just before sowing. Soil applied biofertiizers are mixed in compost or farm yard manure and kept it for overnight and then incorporated in soil just before sowing. Now a days in addition to Nitrogen (N), Phosphorus (P) and Potassium (K) fixing biofertilizer, liquid bifertilizers for sulphur, zinc and manganese are also available. These liquid biofertilizers are easy to handle and cost effective [6]. In India, biofertilizers are available for almost all crops. Hence, total consumption of biofertilizer is expected to increase too many fold in coming years. Various Agricultural State Universities and non-Government Organizations are engaged in mass production of biofertilizers [7-9]. Largest producing states are Madhya Pradesh, Maharashtra, Karnataka and Tamilnadu. The biofertilizer demand in India is several thousand tones, but no sufficient production facilities are available.

Characteristics of liquid biofertilizers

Dormant microorganisms: In their dormant state, these microorganisms can survive in the liquid formulation and remain viable until they are introduced

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into the soil. Upon reaching the soil, they reawaken, germinate and multiply, utilizing available carbon sources from the soil or root exudates to become active.

Extended shelf life: Liquid biofertilizers typically have a shelf life of 12 to 24 months, which is significantly longer than that of traditional carrier-based biofertilizers. This extended shelf life is due to the dormant state of the microorganisms and the formulation's stability.

Temperature tolerance: They can withstand higher temperatures up to 45°C without losing their efficacy, which is not the case for many carrier-based products.

Low contamination risk: The liquid format minimizes the chances of contamination compared to carrier-based biofertilizers.

High population density: Liquid biofertilizers can maintain high populations of beneficial microorganisms, often exceeding 10^9 cells per unit, ensuring effective inoculation and impact.

Reduced dosage: The required dosage for liquid biofertilizers is about ten times less than that of carrier-based inoculants, making them more efficient and cost-effective.

Quick quality control: The liquid formulation simplifies quality control procedures, making it easier to ensure product consistency and effectiveness.

Seed treatment

Nitrogenous biofertilizers: Apply at 200 gm/10 kg seeds.

Phosphatic biofertilizers: Apply at 200 gm/10 kg seeds.

Liquid biofertilizer: Dip seeds in a solution of 3 ml of liquid biofertilizer per liter of water.

Soil treatment

4 kg each of the recommended biofertilizers are mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

DISCUSSION

Challenges of biofertilizers development and use

Biofertilizers represent a biological approach aimed at the sustainable intensification of agriculture, offering an eco-friendly alternative to synthetic fertilizers. Despite their potential benefits, several challenges hinder their widespread application and effectiveness in boosting agricultural yields.

Variable performance under field conditions: Biofertilizers are highly sensitive to both biotic and abiotic stresses. While they may demonstrate promising results in laboratory and greenhouse settings, their performance often varies significantly in actual field conditions. Crops are grown in diverse environments with varying temperatures, rainfall, soil types, soil biodiversity and crop varieties. These environmental variations can lead to inconsistencies in the efficacy of biofertilizers, making it challenging to ensure reliable results across different settings.

Slower action compared to synthetic fertilizers: Biofertilizers generally act more slowly than synthetic fertilizers. The inoculum in biofertilizers needs time to establish itself, build up its population and effectively colonize plant roots. This delayed action can impact their adoption among farmers who may be accustomed to the immediate results provided by synthetic alternatives.

Need for field-specific research: To address these challenges, it is essential to select potential biofertilizer isolates based on their performance under various field conditions. This involves testing them across multiple crops, soil types and environmental conditions to identify those that offer consistent benefits. Biofertilizers should ideally complement rather than completely replace synthetic fertilizers, helping to reduce their usage and associated environmental impacts.

Shelf life and storage issues: Biofertilizers contain live microbial cells, which pose challenges related to shelf life and storage. Typically, they have a short shelf life of around six months when stored at 20°C-25°C. This necessitates careful handling, transportation and storage to maintain their viability, which can increase product costs and limit availability, especially in remote rural areas.

Regulatory and standardization barriers: The development and commercialization of biofertilizers face regulatory hurdles, including difficulties in product registration and patenting. One major issue is the lack of standardized legal and regulatory definitions for terms such as "plant biofertilizer" or "plant biostimulant". This absence of a globally coordinated regulatory framework creates inconsistencies and barriers to market entry, complicating the commercialization process [10-12].

Future prospects of biofertilizers

There is a growing demand for agricultural goods produced in a sustainable manner; therefore, the use of eco-friendly inputs for food production, such as biofertilizers, will have a significant increase in the coming years. The global market of biofertilizers is expected to increase from 2.3 billion US dollar in 2020 to 3.9 billion in 2025. The increase in the market value will be supported by government agencies and industry to create awareness among farmers and consumers about the benefits of the use of biofertilizers, in concordance with the development sustainable goal 12 proposed by FAO: "ensure sustainable consumption and production patterns. The role of metagenomics to have a better understanding of microbial communities associated with rhizosphere is a growing field of research and it will continue to increase. Plant rhizosphere is colonized by a large number of microorganisms and this results in a huge number of microbial genes that interact with plant genes. However, more elaborated research has to be conducted, such as meta transcriptomic and meta proteomics and their relation with plant growth. The results of the omics must be translated into the field to have better agronomic practices and new biofertilizer formulations.

CONCLUSION

In conclusion, the increasing reliance on chemical fertilizers in modern agriculture has raised significant concerns regarding soil health, environmental impact and the long-term sustainability of farming practices. To reduce this, the integration of biofertilizers, which are eco-friendly and renewable, offers a potential solution. Biofertilizers, derived from naturally occurring microorganisms, contribute to maintaining soil fertility, promoting healthier crop growth and reducing the negative environmental effects linked to synthetic fertilizers. Despite challenges such as variability in field performance, slower nutrient release and regulatory hurdles exist, the potential of biofertilizers remains positive. The growth will be supported by ongoing research and technological advancements that aim to improve the efficiency and reliability of biofertilizers. By harnessing the benefits of biofertilizers and overcoming existing challenges, they can play a pivotal role in sustainable crop production, soil health preservation and environmental protection, making them an indispensable component of future agricultural strategies.

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REVIEW ARTICLE

Nitrogen management in maize in semi-arid region

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Verma L, Kumar V. Nitrogen management in maize in semi-arid region. AGBIR.2024;40(4):1188-1190.

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions and successful cultivation in diverse seasons and ecologies for various purposes. Globally, maize is known as "Queen" of cereals because it has the highest genetic yield potential among the cereals. Maize is also known as *Drosophila* of crops. It efficiently utilizes solar energy and has immense potential for higher yield, so called as "Miracle crop". Maize ranks third in India in terms of production among cereals, among the three major fertilizers, nitrogen, phosphate and potassium, application of nitrogenous fertilizers is the maximum. It is reported that China, India and Pakistan together consume approximately 70% of nitrogen fertilizer consumed globally. These figures of nitrogen fertilizer consumption point towards emerging environmental pollution issues.

Key Words: *Leaf colour chart; Maize; Nitrogen use efficiency; Split application*

INTRODUCTION

In this study, Nitrogen (N) application to maize tended to improve vegetative growth. The response to nitrogen increased as level of nitrogen applied increased. Thus it is feasible to recommend nitrogen application to maize under similar conditions. In our survey area, the main fertilizer used at seeding is Diammonium Phosphate (DAP) and the main topdressing fertilizer is nitrogen, including predominant use of urea and ammonium bicarbonate. Potassium fertilizer application has been largely ignored on grain crops. Urea and other nitrogenous fertilizers are the need of the hour due to increased population and nutritional demand, but not at the cost of environmental health and life of living organisms. The blind use of nitrogenous fertilizers is only due to lack of scientific knowledge and awareness, poor management practices, greediness and illiteracy among farmers [1].

In case of semi-arid regions, due to high accumulation of soil NO_3-N were indicated the leaching losses by the excessive nitrogen applications and residual soil NO_3-N contents after harvest and apparent nitrogen losses markedly increased with increased nitrogen fertilizer rate. Excessive use of nitrogenous fertilizers and other chemical fertilizers affect these invaluable soil microflorae and the result is unproductive land with less or no water holding capacity increases tissue succulence in crop plants and make them susceptible to diseases and pests. The increased condition succulence of plant tissues helps in pests and pathogens entry and multiplication easier therefore increasing the susceptibility. The nutrients lost by runoff and leaching due to excessive application of chemical fertilizers also adds to environmental pollution. This excess nitrogen reaches water bodies destroying flora and fauna and causes many deadly diseases to human beings and water and air contaminated [2].

LITERATURE REVIEW

In recent years concern has grown over the contribution of Nitrogen (N) fertilizers to the environmental problems of nitrate pollution of waters and the pollution of the atmosphere with nitrous oxide, other oxides of nitrogen and ammonia. considering of these concerns, proposals to mitigate these problems have been considered and others will be advancing. When they have been used in high amounts, fertilizers and animal manures have created problems of nitrate pollution. Nitrous oxide (N_2O) is a greenhouse gas and may also contribute to the destruction of the stratospheric ozone when it is converted to nitric oxide. N_2O is primarily produced in the biological processes of nitrification and denitrification. Nitric oxide and nitrogen dioxide are also produced in biological processes and are important in atmospheric reactions in the troposphere and stratosphere. There is little indication that nitrogen fertilizers contribute very much to the production of nitrous oxide.

More research is needed to characterize and measure the emissions of the oxides of nitrogen and ammonia and to make better estimates of global emissions based on process-related models. More efforts to increase the efficiency of nitrogen fertilizer use through modifications or use of inhibitors of biological processes as well as better management of rates, timing and incorporation are needed to ensure increased food production while conserving natural resources. Different agronomic options are being recommended which make a way of precision application of nitrogen by using split application at different stage of crop cycle.

Further leaf colour chart and Normalized Difference in Vegetative Index (NDVI) and pursue usefulness for real time nitrogen management by matching time of fertilizer application with maize plant need. Leaf Color Chart (LCC) for maize is under development and being standardized for a number of varieties by Punjab Agricultural University (semi-arid region), Ludhiana. By matching the leaf color of their crop from 10-12 randomized sites in their field (by passing the diseased plants) with the color of chart; farmers can find the required dose of fertilizers application at specific site or plant. By using standard leaf color chart we can predict the amount of nitrogen required in the field or the individual plant [3]. This will have a check on the undue use of urea in the field.

Recent methods of application like fertigation would help in increasing the nutrient use efficiency along with reducing the losses. Fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer solution is distributed evenly in irrigation. The availability of nutrients is very high therefore the efficiency is more. In this method liquid fertilizer as well as water soluble fertilizers are used. By this method, fertilizer use efficiency is increased from 80%-90%. Practicing fertigation is beneficial to farmers in timely and site specific application of nutrients. Application of exact quantity of fertilizers according to soil nutrient status based on soil tests will not only result in proper supply of deficient nutrient elements essential for profitable crop production but also saves cost by supply of precise amount of nutrients as per the nutrient supplying capacity of the soil. New schemes like soil health cards (launched in February, 2015) by the government of India to improve the soil health of the individual farmer's land. Advice on handling particular kinds of soil are then handed over in form of soil health cards to the farmers to serve as a guiding tool to apply fertilizers for various crops. Mobile van soil testing facility is also available under the scheme [4].

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Split Nitrogen (N) fertilizer applications can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible. Dividing total nitrogen application into two or more treatments can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. Study in Marathwada region have shown that splitting of total recommended nitrogen into three equal proportions and applying as basal, 30 Days After Sowing (DAS) and at 60 DAS found to produce highest yield attributes along with high Nitrogen Use Efficiency (NUE) and observed that band placement of the fertilizer showed the better results, instead of other methods. Band placement reduce the denitrification, volatilization and leaching losses. By more specifically synchronizing nitrogen supply with a plant's ability to utilize nutrients, split application can be an important component of 4R nutrient stewardship-right source, right rate, right time and right place. Depending on soil type, climate, agronomic practices and other factors, nitrogen fertilizer can be vulnerable to loss. Denitrification, leaching and volatilization impose costs that include lost productivity and negative environmental impact. Split-applying nitrogen fertilizer is one way to confront these challenges. When a crop's total nitrogen requirement is supplied with a single pre-plant or at planting application, most of the nitrogen must wait for the target crop's future needs and that means the window for potential loss remains open longer. By postponing a portion of the nitrogen treatment until the crop is better able to utilize the nutrient, plants take up the nitrogen more quickly and efficiently. That means growers get more from their fertilizer investment and fertilizer losses that can contribute to environmental concerns are lessened [5].

DISCUSSION

Enhanced nitrogen efficiency with split applications

Agriculture faces the daunting challenge of meeting food, forage and fiber needs in a manner that is both environmentally and economically sustainable while striving to increase productivity with more efficient use of resources. Fertilizer is an integral part of this quest and the adoption of research-based Best Management Practices (BMPs), such as split fertilizer application, reward farmers and consumers alike. To "split-apply" nitrogen, growers make two or more fertilizer applications during the growing season rather than providing all of the crop's nitrogen requirements with a single treatment prior to or at planting. When all of the nitrogen is supplied ahead of crop growth, more of that nitrogen is susceptible to denitrification, leaching or volatilization. Different growing environments pose different potential nitrogen loss conditions nitrogen leaching beyond the root zone for instance, is most likely in lighter textured soils not inhibited by a clay layer but almost all growers face the possibility of losing some of the nitrogen they apply. By splitting the nitrogen application and put a portion on later, almost all of that second application will be taken up by the plant [6].

Consider split application crop-by-crop

Split application offers efficacy benefits on a wide range of crops and forages but its management must be considered on a crop-by-crop basis. The timing of post-planting nitrogen applications is especially critical. The target species must be immature and growing to provide time for the nitrogen to be absorbed and metabolized in order to have the most efficient yield or quality impact. In the case of corn, for instance, all of the nitrogen should be delivered to the plant before ears are set. All crops however, have different nutrient requirements. Because of a need for continuous, in-season production, forages especially benefit from split-applying nitrogen.

Source and placement important

As in all fertilization strategies, source, rate, time and place should be the foundation of split fertilization decisions. Although various forms of nitrogen granular, liquid and anhydrous can be utilized in a split application scenario, their placement is critical. Anhydrous for example, can be used on row crops but should be injected into the soil and therefore, protected from loss. Urea spread over the top for the second in-season application is vulnerable to surface volatilization. Just like the crops they nourish, different nitrogen sources have different characteristics. Ammonium forms are less likely to emit Greenhouse Gases (GHG) and are less vulnerable to denitrification than are nitrate fertilizers. Preferably, urea-containing fertilizers should be applied when soil incorporation by rainfall or irrigation is likely within 24-48 hours, or incorporated by tillage. This is especially important in environments favorable to ammonia volatilization.

Better yields, less nitrogen loss

We get a lot of denitrification in our area and if we don't use the nitrogen, we lose it. By putting nitrogen on when the plant can fully utilize it, we get better efficiency and we see better yields. When that corn plant is about 10-12 inches tall, it's at a stage that it's really ready to charge. It's really ready to take advantage of the nitrogen and it's going to use it up. The first split application is applied, in the form of anhydrous, as close to planting as possible in order to minimize nitrogen losses. A starter is used through the planter and the application at 10-12 inches provides the final boost for optimum yields.

Use research-based recommendations

Split application should not exceed total test-based nitrogen recommendations. While split-applying nitrogen can enhance efficiency, it does not change what the plant needs and should not be used to exceed recommendations. Split fertilizer application can be an important part of a successful nutrient management program and can help growers achieve 4R concept. Farmers should consult local or regional agronomic research to identify the Best Management Practices (BMPs) involved with split application as well as its specific use and benefits for the crops they grow. Hence farmers are guided by own wisdom and practices of fellow farmers when it came to application manures and pesticides. They often have no idea what is the soils inherent capacity to supply nutrients and at what it is deficient in and often end up following the wrong practices. Hence, it is very essential to have knowledge on economic and efficient use of nitrogenous fertilizers so that many adverse effects of excess nitrogen usage on living organisms may be avoided without compromising on yield. A large number of new technologies have evolved and are continuously being used in educating farmers on economic use of nitrogen fertilizers and some of these tools and techniques are discussed below for the benefits of farmers. In advance more research work including breeding and technical aspect is required for sustainable maize production with efficient nitrogen management without degradation of environmental components. Plant breeding can be a powerful tool to bring "harmony" between agriculture and the environment, but partnerships and cooperation are needed to make this a reality. The opportunities to improve nitrogen management as producing more efficient plants and more efficient management [7-9].

Research is needed to better understand and manage microbial mediated processes, e.g. the manipulation of Microbial Inoculant Technology (MIT) and dissimilatory nitrate reduction to ammonia to reduce denitrification and conserve nitrogen. Sensors to measure real-time nutrient availability driving multi-nutrient decision support systems linked to precision application would improve nutrient use in conventional farming and plant breeding for NUE, especially for better root distribution and nutrient uptake rather than just yield, would benefit all farm systems. Nutrient management on farms is under the control of the land manger, the most effective of whom will already use various decision supports for calculating rates of application to achieve various production targets. Increasingly, land managers will need to conform to good practice to achieve production targets and to conform to environmental targets if they are to achieve the objective of sustainable farm systems. follow the balanced nutrition practices and applying the proper rate of nitrogen has a greater influence on drainage water nitrate losses than any other nitrogen management factor including application timing, placement, source or nitrification inhibitors. Many studies show drainage nitrate concentration and loading decrease as nitrogen fertilization rate decreases and improving the nutrient management by the strategic approaches, precision farming and nitrification inhibitors [10].

CONCLUSION

In conclusion, Maize (*Zea mays* L) is a highly adaptable and productive crop with significant genetic yield potential, making it a key player in global cereal production. However, the extensive use of nitrogen fertilizers, particularly in countries like China, India and Pakistan, raises significant environmental risks, including water pollution and greenhouse gas emissions. This study underscores the importance of optimizing nitrogen use through split applications and precision methods to enhance NUE while mitigating adverse environmental impacts. Split nitrogen application, when timed appropriately, can maximize nutrient uptake and reduce losses through denitrification, volatilization and leaching. Incorporating tools like the LCC and adopting advanced techniques such as fertigation can further

improve nutrient management. Additionally, research into MIT and real-time nutrient sensors can provide valuable insights and support precision agriculture practices. Effective nutrient management ensures higher yields while protecting environmental health, aligning agricultural productivity with ecological stewardship.

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RESEARCH ARTICLE

Enhancing soil fertility, yield and quality in green gram (*Vigna radiata* L. Wilczek) through integrated nutrient management

Vijay Kumar*

Kumar V. Enhancing soil fertility, yield and quality in green gram (*Vigna radiata* L. Wilczek) through integrated nutrient management. AGBIR.2024;40(5):1308-1310.

A field experiment was conducted at on clay loam soil. The experiment was laid out according to factorial randomized block design with three replications. The experiment comprised four fertility levels (75% Recommended Dose of Fertilizers (RDF), 75% RDF+Vermicompost (VC) at 2 t ha^{-1}, 100% RDF and 100% RDF+VC at 2 t ha^{-1}) and four biofertiliizers levels (control, *Rhizobium*, Phosphate Solubilizing Bacteria (PSB) and *Rhizobium*+PSB) were applied to the green gram variety SML-668. The RDF was 20 kg Nitrogen (N_2) and 40 kg Phosphorus Pentoxide (P_2O_5) per hectare. The soil of the experimental site was clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium and Diethylene Triamine Pentaacetic Acid (DTPA) extractable micronutrients sufficiently above the critical limits. The main findings of investigation are summarized as: The application of fertility level significantly increased the dry matter accumulation, number of pods per plant, number of seeds per pod, chlorophyll content, seed and haulm yields, nitrogen, phosphorus, potassium, copper, zinc, iron and manganese content and uptake in seed and haulm, protein content in seed, number of total and effective root nodules, fresh and dry weight of root nodules, leghemoglobin content in root nodules and net returns up to 75% RDF+VC at 2 t ha^{-1} however, their further increase with application of 100% RDF+VC at 2 t ha^{-1} was non-significant. The increase in test weight was found non-significant. The organic carbon, available nitrogen, phosphorus, potassium, copper, zinc, iron and manganese in soil increased significantly with the application of fertility levels at harvest of the crop, but Electrical Conductivity (EC) and pH remain non-significant. Seed inoculation with *Rhizobium*+PSB significantly increased the dry matter accumulation, number of pods per plant, number of seeds per pod, chlorophyll content, seed and haulm yields, nitrogen, phosphorus, potassium, copper, zinc, iron and manganese content and uptake in seed and haulm, protein content in seed, number of total and effective root nodules, fresh and dry weight of root nodules, leghemoglobin content in root nodules and net returns and the test weight and harvest index were found non-significant. The organic carbon, available nitrogen, phosphorus, potassium, copper, zinc, iron and manganese in soil significantly increased with inoculation of *Rhizobium*+PSB at harvest stage of the crop, but EC and pH remain non-significant. The interactive effect of fertility levels and biofertilizers significantly influenced the seed and haulm yield, nitrogen, phosphorus, potassium uptake by seed and net returns and maximum being with the application of 100% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB combination (F_4B_3), which was at par with 75% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB combination (F_2B_3).

Key Words: *Greengram; Integrated nutrient management; Fertility; Biofertilizer;* Rhizobium

INTRODUCTION

Green gram (*Vigna radiate* L. Wilczek) commonly known as mung bean and golden gram, is one of the important kharif pulse crop. It ranks third among all pulses grown in India after chickpea and pigeon pea. It is quite versatile crop grown for seeds, green manure and forage; as mixed or sole crop either on residual moisture of the previous crop or as a catch crop to make use of the land left fallow between two main season crops. It makes a good manure if incorporated into soil. Further, it enriches the soil by atmospheric nitrogen fixation through root nodules. The crop gives such a heavy vegetative growth and covers the ground so well that it checks the soil erosion in problem areas and can later be ploughed down for green manure. It has considerable potential as an alternative pulse crop in dry land farming. This crop is of great importance because of availability of short duration (65-70 days), high yielding and quick growing varieties [1].

In India, mung bean growing states are Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Odisha. Rajasthan ranks first in area, while Maharashtra ranks first in production. Kerala is the leading state in productivity with an average of 824 kg ha^{-1} whereas, the national average is 548 kg ha^{-1}. Although green gram is a legume and capable of fixing atmospheric nitrogen, still it responds to small quantity of nitrogenous fertilizers applied as starter dose. In terms of significance, phosphorus is most indispensable mineral nutrient for pulse crops as it helps in better root growth and development and thereby making them more efficient in biological nitrogen fixation. Phosphorus is an essential constituent of nucleic acids such as Ribonucleic Acid (RNA) and Deoxyribonucleic Acid (DNA), Adenosine Diphosphate (ADP) and Adenosine Triphosphate (ATP), nucleoproteins, amino acids, proteins, phosphatides, phytin, several co-enzymes *viz.* thiamine, pyrophosphate and pyrodoxyl phosphate [2,3].

MATERIALS AND METHODS

In order to determine the physico-chemical properties of soil, soil samples (0 cm-15 cm depth) were collected from different spots of the experimental field prior to sowing and fertilization. A representative composite soil sample was prepared by mixing all these samples together. The soil sample after drying was passed through 2.0 mm sieve and then subsequently used for mechanical, physical and chemical analysis. The experimental site soil was clay loam in texture, slightly alkaline in reaction. The soil was medium in available nitrogen, phosphorus while high in potassium and sufficient in DTPA extractable micronutrients.

To assess the fertility status of soil, the soil sample (0 cm-15 cm depth), from each plot at harvest of crop was taken. The samples were passed through 2 mm plastic sieve to avoid metallic contamination. The soil sample were analysed for EC, pH and Organic Carbon (OC) and available Nitrogen, Phosphorus, Potassium (NPK) and cationic micronutrients (Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn)) content as per methods [4].

The experiment was laid out in factorial randomized block design with three replications. The treatment combinations were randomized with the help of randomization technique.

Treatment application

Fertility levels: Nitrogen and phosphorus were applied through urea and Diammonium Phosphate (DAP), respectively as per treatments as basal doses at the time of sowing. Whole amount of vermicompost as per treatment was broadcasted uniformly at the time of sowing and incorporated in the soil.

Biofertilizer levels: The required seeds were treated with bavistin at 2 g/kg

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of seed to control seed borne diseases. Later on seeds were inoculated with *Rhizobium* and PSB culture or both as per treatments, using standard method and dried in shade.

Seed rate and sowing

The seeds were sown by 'kera' method with row spacing of 30 cm by hand plough at a depth of 5 cm using a seed rate of 20 kg ha^{-1}. The variety of green gram (SML-668) was used as the test crop and the sowing was done on 18 July 2015.

Thinning, hoeing and weeding

To maintain uniform plant, stand at an intra-row spacing of 10 cm, extra plant was thinned out 10 days after sowing (DAS). In order to minimize weed competition, weeding and hoeing was done manually 19 and 28 days after sowing to facilitate aeration and removal of weeds.

Harvesting

The crop was harvested from net plot area separately from each plot. The harvested material of each plot was tied up in bundles and tagged.

Statistical analysis

Analysis of variance and test of significance: In order to test the significance of variation in experimental data obtained for various treatment effects. The critical differences were calculated to assess the significance of treatment mean wherever the 'F' test was found significant at 5% level of probability. To elucidate the nature and magnitude of treatment effects, summary tables along with Standard Error of the mean (SEm) ± Critical Difference (CD) (p=0.05) were prepared and are given in the text of the chapter "results" and their analyses of variance are given in appendices at the end.

Economics of treatments: The economics of treatments is the most important consideration making any recommendation to the farmers for its wide adoption. For calculation of economics, the average treatment yield along with prevailing market rates for inputs and outputs were used. Hence, to evaluate the effectiveness and profitability of the treatments comprehensive economics including net returns and Benefit cost (B/C) ratio was calculated so that most effective and remunerative treatment could be recommended. The details of calculation are given in appendices at the end [5-7].

RESULTS AND DISCUSSION

The data related to various criteria used for treatment evaluation were analysed statistically using standard statistical methods to test their significance. The data regarding the effect of fertility and biofertilizer levels on net return and benefit cost ratio of green gram are being summarized in Table 1.

Net return

Effect of fertility levels: A perusal of data in Table 1, revealed that with the application of fertility levels, the net return under 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) treatments significantly increased as compared to 75% RDF. However, the increase in net return with 100% RDF+vermicompost (2 t ha^{-1}) was statistically at par with 75% RDF+vermicompost (2 t ha^{-1}). The application of 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) increased the net return to the tune of 28.98%, 14.51% and 36.63% respectively, over 75% RDF [8-10].

Effect of bioferilizers: A critical examination of data in Table 1, revealed that due to inoculation of green gram seed with *Rhizobium*, PSB and *Rhizobium*+PSB, the net returns significantly increased in comparison to control. Further, the increase in net returns with *Rhizobium*+PSB was statistically significant over *Rhizobium* as well as PSB inoculations. However, the increase in net returns with inoculation of *Rhizobium* was statistically at par with that of PSB. The extent of increase in net return of green gram with *Rhizobium*, PSB and *Rhizobium*+PSB inoculation was 38.31%, 33.14% and 54.57% respectively over control.

Interactive effective of fertility and biofertilizer levels: The interactive effect of fertility and biofertilizer levels on the net returns was found significant (Table 2). The significantly highest net returns were obtained under treatment combination F_4B_3, which was at par with the treatment combinations of F_2B_3. Minimum net returns were recorded under F_1B_0 treatment.

Benefit cost ratio

Effect of fertility levels: The benefit cost ratio under 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) treatments significantly increased as compared to 75% RDF treatment. The highest B/C ratio (1.80) was recorded with 100% RDF+vermicompost (2 t ha^{-1}). The application of 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) increased the B/C ratio to the extent of 9.32%, 8.07% and 11.80% respectively, over 75% RDF.

Effect of bioferilizers: Due to inoculation of green gram seed with *Rhizobium*, PSB and *Rhizobium*+PSB, the B/C ratio significantly increased in comparison to control. The highest B/C ratio (2.08) was obtained with B_3 (*Rhizobium*+PSB). However, the increase in B/C ratio with inoculation of *Rhizobium* was statistically at par with that of PSB. The extent of increase in B/C ratio with *Rhizobium*, PSB and *Rhizobium*+PSB inoculation was 36.23%, 31.16% and 50.72% respectively, over control [11,12].

The application of 100% RDF+VC at 2 t ha^{-1} to green gram crop significantly increased the net return (38837) and B/C ratio (1.80) over others levels of RDF and vermicompost. Likewise, inoculations of greengram seeds with *Rhizobium*+PSB also significantly increased net returns (40102) and B/C (2.08) ratio over *Rhizobium*, PSB and control (Table 1). It is clear that in both the treatments there was significant increase in seed and haulm yield which ultimately gave more net returns and B/C ratio over the input cost incurred in these treatments in comparison to others treatments. These results are in close conformity with those of Meena et al., [13].

Interactive effect of fertility and biofertilizer levels: The significantly highest net returns (48109 ha^{-1}) and B/C ratio (2.22) were obtained with combined use of 100% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB (F_2B_3), which were significantly higher as compared to other treatment combinations (Table 2). However, it is at par with F_2B_3 (44987 ha^{-1}). It is obvious because the seed and haulm yield of green gram also increased significantly under this treatment which is main contributor to net returns and thus resulted in higher net returns under application of 100% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB. These results are in close conformity with those of Meena et al., [13].

TABLE 1

Effect of fertility and biofertilizer levels on net returns and benefit cost ratio

Treatments	Net returns (ha^{-1})	B/C ratio
Fertility levels		
F_1: 75% RDF	28424	1.61
F_2: 75% RDF+VC (2 t ha^{-1})	36661	1.76
F_3: 100% RDF	32549	1.74
F_4: 100% RDF+VC (2 t ha^{-1})	38837	1.8
SEm ±	1422	0.04
CD (p=0.05)	4108	0.12
Biofertilizer levels		
B_0: Control	25944	1.38
B_1: *Rhizobium*	35882	1.88
B_2: PSB	34543	1.81

B_3: *Rhizobium*+PSB	40102	2.08
SEm±	1422	0.04
CD (p=0.05)	4108	0.12

Note: RDF: Recommended Dose of Fertilizers; VC: Vermicompost; SEm: Standard Error of the mean; CD: Critical Difference; PSB:Phosphate Solubilizing Bacteria; B/C: Benefit cost.

TABLE 2

Interactive effect of fertility and biofertilizer levels on net returns (ha^{-1})

Treatments	F_1	F_2	F_3	F_4
B_0	24455	26563	25778	26980
B_1	29507	38570	34274	41178
B_2	29106	36524	33462	39081
B_3	30630	44987	36681	48109
SEm ±	2845	-	-	-
CD (p=0.05)	8216	-	-	-

Note: SEm: Standard Error of the mean; CD: Critical Difference.

CONCLUSION

On the basis of one-year field experimentation, it can be concluded that under agro climatic condition of Kanpur, application of 100% RDF+VC at 2 t ha^{-1}+*Rhizobium*+PSB (F_4B_3), is the better option for realizing higher productivity, content and uptake of nutrients, net returns and B/C ratio of green gram and is the better option for improved fertility status of soil. A significant response to the application of aforesaid treatment was observed. However, highest economic green gram seed yield (1386.07 kg ha^{-1}) and net return (48109 ha^{-1}) was observed in treatment combination of F_4B_3 (100% RDF+VC at 2 t ha^{-1}+*Rhizobium*+PSB) with B/C ratio of 2.22, which was at par with F_2B_3 (75% RDF+VC at 2 t ha^{-1}+*Rhizobium*+PSB). The result of the present investigation reveals the significance of fertility levels with the combination of vermicompost and biofertilizer levels in green gram crop for maximization of yield and profits.

However, the highest available nitrogen, phosphorus, potassium, copper, zinc, iron and manganese status of soil after harvesting of green gram crop were observed under fertility level 100% RDF+VC at 2 t ha^{-1} (F_4) and inoculation of *Rhizobium*+PSB (B_3) treatment as compared to 75% RDF (F_1) and control (B_0), respectively.

However, these results are only indicative and require further experimentation for confirmation before making final recommendation to the farmers.

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REVIEW ARTICLE

Plant tissue culture techniques for *in vitro* mass multiplication of *Prosopis cineraria* (L.) in Thar Desert of Rajasthan

Ravi Kumar*, Sunita Bhandari, Sarita

Kumar R, Bhandari S, Sarita. Plant tissue culture techniques for *in vitro* mass multiplication of *Prosopis cineraria* (L.) in Thar Desert of Rajasthan. AGBIR.2024;40(4):1185-1187.

Prosopis cineraria (L.) is commonly known as Khejri or Shami. It is a multipurpose tree species found in arid and semi-arid regions of the Indian subcontinent. Its ecological significance includes soil stabilization and nitrogen fixation, while economically, it provides timber, fuelwood and fodder. Medicinally, various parts of the tree are used in traditional remedies for conditions like diabetes and respiratory ailments. Conventional propagation methods for *Prosopis cineraria* are often inadequate for its large-scale production. *In vitro* tissue culture techniques offer a viable alternative for mass multiplication and conservation of this valuable species. This review provides an in-depth analysis of various plant tissue culture methods employed for the *in vitro* propagation of *Prosopis cineraria*. The review also discusses the challenges, optimization strategies and potential applications of these techniques.

Key Words: *Prosopis cineraria; Tissue culture; Cytokinin; Soil*

INTRODUCTION

Prosopis cineraria (L.), commonly known as Khejri or ghaf, plays a significant role in combating desertification in the Thar Desert of Rajasthan [1]. It is a member of the family Fabaceae. It is widely recognized for its adaptability to harsh environmental conditions, making it a keystone species in the Thar Desert and other arid regions. The Khejri tree is unique in that it thrives in all desert climates. It is known as Kalptaru, which means all parts of the tree are useful. It is also referred to as the "wonder tree" and consequently, the "king of desert" [2-4]. Regular surveys conducted in 2010 in Jodhpur, Nagpur, Sikar, Churu and Jhunjhunu by the Arid Forest Research Institute, Jodhpur, revealed that the percentage mortality of Khejri trees ranged from 18.08% to 22.67%, with an average mortality of 20.93% in these districts [5,6]. This resilient tree species is well-adapted to arid and semi-arid conditions, making it an invaluable asset in the efforts to mitigate the adverse effects of desertification. It reduces desertification through soil stabilization, soil fertility improvement, water conservation, support for biodiversity, provision of economic benefits, carbon sequestration and enhancement of ecosystem resilience. Its multifaceted role underscores the importance of conserving and promoting this tree species in arid regions like Rajasthan. The tree is valued for its nutritional, medicinal and ecological benefits. Despite its importance, natural regeneration is slow and overexploitation has led to its decline. Micropropagation is an effective technique for producing disease-free plants quickly, rare species quickly multiplying, genetically modifying plants and producing bioactive substances produced from plants [7,8]. Tissue culture techniques offer a potential solution for the rapid propagation and conservation of *Prosopis cineraria* [9-11].

LITERATURE REVIEW

Tissue culture techniques

Plant tissue culture involves the *in vitro* cultivation of plant cells, tissues or organs under controlled environmental conditions on a nutrient medium. This method allows for the rapid multiplication of plants and is particularly beneficial for the propagation of species that are difficult to propagate by conventional methods.

Explants selection and preparation: For the micropropagation of *Prosopis cineraria*, the selection of suitable explants is critical. Commonly used explants include nodal segments, shoot tips and cotyledonary nodes. Explants must be sterilized to prevent microbial contamination, typically using a combination of alcohol and sodium hypochlorite [12].

Culture initiation and shoot multiplication: Explants are placed on a nutrient medium supplemented with essential macro and micronutrients, vitamins and Plant Growth Regulators (PGRs) such as auxins and cytokinins. Murashige and Skoog (MS) medium is frequently used for initiating cultures due to its comprehensive nutrient composition [13]. The induction of multiple shoots from the explants is achieved by optimizing the concentration and combination of cytokinins (e.g. Benzylaminopurine) and auxins (e.g. Indole-3-acetic acid). A high cytokinin to auxin ratio typically promotes shoot proliferation. Subculturing the explants onto fresh media every 3-4 weeks ensures continuous shoot multiplication. After pruning thorny mature trees of *P. cineraria*, the nodal shoot section was used to generate the highest number of 10-12 shoots on Murashige and Skoog's (MS) medium, which contained 0.1 mg/l Indole-3-Acetic Acid (IAA)+2.5 mg/l Benzylaminopurine (BAP)+additives [14]. For the purpose of standardizing shoot formation in nodal segment of *Prosopis cineraria*, a variety of auxins, including Naphthalene Acetic Acid (NAA), IAA, IBA and 2,4-Dichlorophenoxyacetic acid (2,4-D) and cytokinins, such as kinetin and BAP, were added to Murashige and Skoog's (MS) medium. It was discovered that 3-Indoleacetic Acid (IAA: 3.0 mg/l) combined with kinetin (0.05 mg/l) was the most effective combination for multiple shoot differentiation [9].

Callus induction, somatic embryogenesis and organogenesis: Callus induction is the initial step in many plant tissue culture processes. It involves the formation of an undifferentiated mass of cells (callus) from explants under controlled conditions. Somatic embryogenesis involves the development of embryos from somatic or non-reproductive cells, which can then develop into complete plants. Organogenesis is the process by which explants form organs like shoots and roots. Direct and indirect organogenesis can be induced by culturing explants or calli on media with specific PGR combinations [15].

Root induction, acclimatization and transfer to soil: Once adequate shoot multiplication is achieved, shoots are transferred to a rooting medium. This medium is generally fortified with auxins such as Indole-3-Butyric Acid (IBA) to induce root formation. Rooting efficiency can be enhanced by adjusting the concentration of IBA and other supplements like activated charcoal to reduce phenolic exudation. For the purpose of standardizing root production, a variety of auxins, including NAA, IAA, IBA and 2,4-D and cytokinins, including kinetin and BAP, were added to Murashige and Skoog's (MS) medium. After differentiation, shoot segments were obtained and multiplied by subculturing on 1/2 MS that was devoid of auxins and cytokinins. In white's base medium containing 0.8% agar, 3.0 mg/l Indole-3-Butyric Acid (IBA) and 0.05 mg/l kinetin, shoot segments spontaneously

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produced tap roots within 15-20 days. With 60% of the rooted plants, transplantation to pots with a soil-vermiculite mixture (3:1) was completed effectively in *Prosopis cineraria* [9]. On MS medium with 0.1 mgl^{-1} NAA+1.0 mgl^{-1} BAP+additives, differentiated shoots multiplied most effectively. After extracting the differentiated shoots, the original explant of *Prosopis cineraria* was transplanted six times on new medium in order to produce multiple shoots. After pulsing 100 mgl^{-1} IBA for 4 hours, shoots were rooted by culture on hormone-free half-strength MS medium [14]. The acclimatization stage is significant for the survival of *in vitro* cultured plants. Plantlets with well-developed roots are gradually acclimatized to *ex vitro* conditions by transferring them to soil or a soil-vermiculite mixture under high humidity and controlled temperature conditions. This step involves gradually reducing humidity to adapt the plantlets to ambient conditions.

DISCUSSION

Applications and benefits in the Thar Desert

Ecological restoration: *Prosopis cineraria* is pivotal in combating desertification and restoring degraded lands in the Thar Desert. Its deep root system stabilizes the soil, reduces erosion and improves water retention.

Livelihood support and food for animals: The tree provides various products such as fodder, fuelwood and medicinal compounds, supporting local livelihoods. Its leaves and pods are highly nutritious for livestock, especially during the dry season when other forage resources are scarce.

Soil fertility enhancement: *Prosopis cineraria* enriches soil fertility through nitrogen fixation and leaf litter decomposition, which adds organic matter to the soil. This improves the soil's physical and chemical properties, promoting the growth of other vegetation (Figure 1).

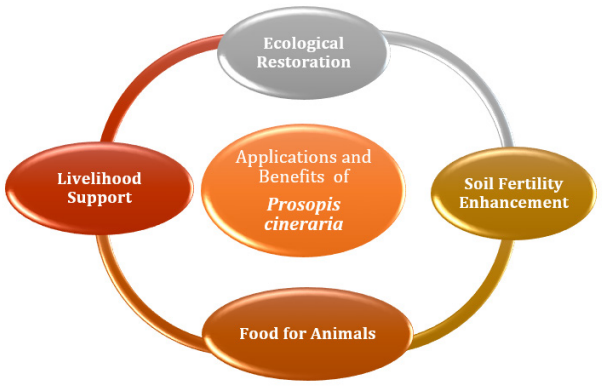


Figure 1) *Applications and benefits of Prosopis cineraria*

Challenges and optimization strategies

Contamination: Contamination is a critical issue in tissue culture, often caused by bacteria, fungi or yeast, which can compromise the culture's success. To address this, surface sterilization of plant material is essential. Mercuric Chloride ($HgCl_2$), though highly effective, is less commonly used due to its toxicity and environmental concerns. Sodium Hypochlorite (NaOCl) is a safer, more widely used alternative, typically applied at 1%-5% concentrations. Both agents work by eliminating surface microorganisms, but proper handling and timing are significant to avoid damaging the plant tissues. Consistent use of these sterilization protocols is key to maintaining aseptic conditions and ensuring culture success.

Somaclonal variation: Somaclonal variation refers to genetic changes that can arise during tissue culture, potentially altering the traits of regenerated plants. This variation may result from stress or genetic instability in the cultured cells. To ensure that tissue-cultured plants maintain the desired genetic characteristics of the parent, regular monitoring is significant. Employing molecular markers such as Polymerase Chain Reaction (PCR) and Simple Sequence Repeats (SSR) allows for precise detection of genetic deviations. These markers help in assessing clonal fidelity, ensuring that the propagated plants are true to type and maintain consistent quality, which is essential for breeding programs and commercial production.

Media optimization: Media optimization is vital for tissue culture success, including macronutrients, micronutrients and Plant Growth Regulators (PGRs), is significant for successful tissue culture. Adjustments must be made continuously based on the type of explant and its developmental stage to promote optimal growth and development.

Acclimatization: Acclimatization involves gradually transitioning *in vitro* plants to *ex vitro* conditions. This process starts with high humidity and reduced light intensity to ease the plants adaptation to external environments. Gradual exposure to these changing conditions helps improve survival rates and ensures a smoother adaptation to natural growth conditions (Figure 2).

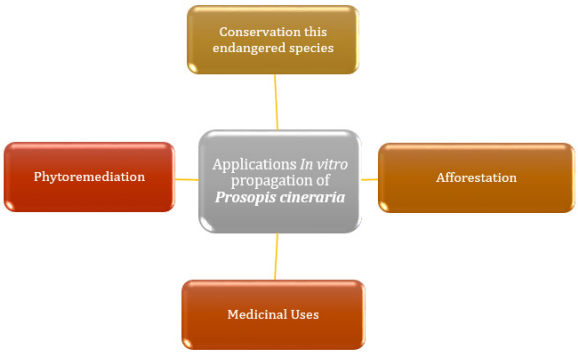


Figure 2) *Applications in vitro propagation of Prosopis cineraria*

Applications

In vitro propagation of *P. cineraria* has numerous applications as follows:

Conservation: *Prosopis cineraria* is a significant species for arid and semi-arid ecosystems, but it is endangered due to habitat loss and other environmental pressures. *In vitro* propagation, which involves growing plants in a controlled, sterile environment, is essential for its conservation. This technique enables the mass multiplication of the species, thus creating large numbers of genetically identical plants that can be reintroduced into their natural habitats. This approach helps in preserving the genetic diversity and ensuring the survival of the species in the wild.

Afforestation: Rapid propagation through tissue culture supports large-scale afforestation projects, especially in arid and semi-arid regions where *Prosopis cineraria* is naturally adapted. By generating a high volume of seedlings quickly and efficiently, *in vitro* propagation facilitates the restoration of degraded lands and contributes to the greening of these challenging environments. This not only helps in combating desertification but also in enhancing local biodiversity and improving soil quality.

Phytoremediation: *Prosopis cineraria* is well-suited for phytoremediation, a process where plants are used to clean up contaminated soils or water. The species' ability to thrive in degraded soils and tolerate harsh conditions makes it a valuable candidate for such projects. *In vitro* propagation ensures a consistent supply of healthy plants that can be used in these remediation efforts, helping to restore soil fertility and remove pollutants from the environment.

Medicinal uses: *Prosopis cineraria* has a history of use in traditional medicine and *in vitro* propagation supports the consistent supply of plant material for the extraction of bioactive compounds. These compounds are used in various medicinal preparations, including treatments for ailments such as inflammation, diabetes and gastrointestinal issues. By providing a steady source of high-quality plant material, tissue culture helps ensure that traditional medicinal practices can continue effectively and sustainably.

CONCLUSION

Prosopis cineraria or Khejri, is a vital species for arid and semi-arid regions due to its ecological, economic and medicinal benefits. Its role in soil stabilization, nitrogen fixation and provision of essential resources underscores its importance in combating desertification and supporting local livelihoods.

However, traditional propagation methods are often inadequate for its large-scale production. *In vitro* tissue culture techniques offer an effective solution for the rapid and disease-free multiplication of *P. cineraria*. These methods, while potential, face challenges such as contamination and somaclonal variation, which require ongoing optimization. Successful implementation of tissue culture can significantly enhance conservation efforts, support afforestation projects and provide a consistent supply of plant material for medicinal uses, thereby ensuring the sustainability and continued utility of this significant species.

Tissue culture techniques offer a sustainable and efficient method for the mass multiplication of *Prosopis cineraria*. Advances in callus induction, somatic embryogenesis, organogenesis and micropropagation have significantly improved propagation efficiency. Despite challenges such as contamination and somaclonal variation, ongoing research and optimization continue to enhance the effectiveness of these techniques. The application of *in vitro* propagation methods can play a pivotal role in the conservation, afforestation and utilization of *Prosopis cineraria*.

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REVIEW ARTICLE

Effect of heat stress on wheat production in semi-arid region of Rajasthan

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Kumar R, Bhandari S, Sarita, et al. Effect of heat stress on wheat production in semi-arid region of Rajasthan. AGBIR.2024;40(4):1210-1213.

Producing sufficient food to meet the demands of India's growing population, projected to reach 10 billion by 2050, presents significant challenges due to declining arable land, water scarcity and unpredictable weather patterns magnified by climate change. Wheat (*Triticum aestivum* L.), a staple crop providing 20% of global caloric and protein intake, faces severe threats from heat stress, which has already reduced global productivity by approximately 5% since the 1980s. This review examines the impact of heat stress on wheat production, focusing on physiological, biochemical and yield-related aspects, with a particular emphasis on the semi-arid region of Rajasthan, India. High temperatures during significant growth stages disrupt photosynthesis, reduce enzymatic activities and alter starch accumulation in grains, ultimately decreasing yield and grain quality. Additionally, heat stress induces oxidative damage through the accumulation of Reactive Oxygen Species (ROS), impacting membrane stability and protein expression. The synthesis of Heat Shock Proteins (HSPs) plays a vital role in mitigating heat-induced damage, although their efficacy is often overwhelmed under extreme stress. This review underscores the necessity of developing heat-tolerant wheat cultivars to sustain productivity in the face of rising temperatures and highlights the complex exchange between temperature stress and wheat physiology.

Key Words: *Heat stress; Photosynthetic efficiency; Anthesis; Reactive oxygen species; Heat shock proteins*

INTRODUCTION

The most significant task of the century is to produce sufficient food to feed India's increasing population, while also coping with decreasing amounts and quality of arable land, reducing water supplies and increasingly unpredictable weather due to climate change [1]. According to Food and Agriculture Organization (FAO) estimates, in order to meet future demand, the world will need an extra 198 million tons of wheat by 2050, meaning that developing nations' wheat production will need to rise by 77% [2]. About 30% of the world's cereal acreage is devoted to the primary, stable crop of wheat, which feeds 36% of the world's population. About 20% of the calories and proteins in a human diet come from wheat. Heat stress is estimated to have decreased global wheat productivity by as much as 5% since the 1980s [3,4]. Based on the severity of the high temperature, drought, salinity, waterlogging and mineral toxicity stresses, such an increase in world's temperature may have a major impact on productivity. High temperature-induced heat stress is defined as an increase in air temperature that lasts longer than a certain threshold and is strong enough to harm or permanently damage agricultural plants in general [5]. The issue of heat stress is made worse when soil temperature rises due to an increase in air temperature and a decrease in soil moisture. As a result, heat stress has emerged as a serious threat to worldwide crop productivity [6-9]. Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world, providing essential nutrients to a large part of the global population. In Rajasthan, wheat occupies a significant portion of the cultivated land, contributing substantially to the state's economy and food security. However, the semi-arid climate of Rajasthan, characterized by high temperatures and low rainfall, increases the challenges of wheat production. Heat stress in particular is a significant factor that affects the growth, development and yield of wheat. The climate in Rajasthan is predominantly dry and hot, with temperatures often exceeding 40°C during the wheat growing season. The region receives an annual rainfall of approximately 250-500 mm, which is sporadic and unpredictable. These climatic conditions create a challenging environment for wheat cultivation, making the crop highly susceptible to heat stress. Heat stress affects wheat at various developmental stages, leading to a range of physiological responses. High temperatures during the germination phase can lead to reduced germination rates and poor seedling vigor. Heat stress affects the enzymatic activities essential for seed germination, resulting in delayed or uneven crop establishment. Wheat production in India had observed a quantum jump from 6.5 million tons in 1950 to 112 million tons in 2023. A 33% yield loss in late-sown wheat varieties was noted as a result of high temperatures, suggesting the necessity to produce heat-tolerant wheat cultivars in order to achieve sustainable production. The climate agency said that "the global average temperature for the past 12 months (April 2023-March 2024) is the highest recorded at 0.70°C above the 1991-2020 average and 1.58°C above the 1850-1900 pre-industrial average. The 60%-70% starch content of wheat grains steadily decreases at high temperatures. Because granule-bound starch, soluble starch and sucrose synthase are inactive during the grain filling phase, high temperatures prevent starch from building up in grains. Additionally, it reduces the synthesis of starch, translocates carbohydrates from stem reserves and modifies the structure of the seed's endosperm and aleurone layer, all of which have an impact on the growth of grains [10-13].

LITERATURE REVIEW

Physiological impact

Since photosynthesis is the physiological activity most susceptible to temperature changes, any decrease in photosynthesis has an impact on wheat growth and grain yield [14-16]. Heat stress impairs the photosynthetic efficiency of wheat plants by affecting chlorophyll content and disrupting the functioning of photosystem II [17]. The heat-induced increase in thylakoid membrane fluidity and Photosystem II's (PSII's) electron-transport dependent integrity are the main causes of PSII's vulnerability to high temperatures [18]. A notable rise in the baseline level of chlorophyll fluorescence, which is indicative of photosynthetic inhibition, is frequently used to suggest the inhibition of PSII electron transport during heat stress [19]. We must know how crops respond to elevated temperatures and how tolerance to heat can be improved in order to adapt new crop varieties to the future climate [20]. The best temperature for wheat anthesis and grain filling is between 12°C and 22°C. Exposure to temperatures higher than this can drastically reduce grain yield [21-23]. Heat stress affects grain growth because temperature variations directly affect assimilate translocation and the length and pace of grain filling. The degree of heat stress determines how much harm is caused by heat. Increased respiration rates under high temperatures lead to a depletion of carbohydrates, which adversely affects plant growth and development [24]. Wheat plants under heat stress exhibit reduced water uptake and increased transpiration rates, leading to a negative water balance [25]. Stomatal closure, a common response to heat stress, further reduces CO_2 assimilation, impacting photosynthesis and overall plant productivity (Table 1) [26].

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TABLE 1
Optimal temperature requirements of wheat at different growth stages

Stages	Optimum temperature (°C)	Minimum temperature (°C)	Maximum temperature (°C)
Root growth	17.2 ± 0.87	3.5 ± 0.73	24 ± 1.21
Shoot growth	18.5 ± 1.90	4.5 ± 0.76	20.1 ± 0.64
Leaf initiation	20.5 ± 1.25	1.5 ± 0.52	23.5 ± 0.95
Terminal spikelet	16 ± 2.3	2.5 ± 0.49	20 ± 1.6
Anthesis	23 ± 1.75	10 ± 1.12	26 ± 1.01
Grain filling duration	26 ± 1.53	13 ± 1.45	30 ± 2.13

Biochemical impact

Heat stress triggers several biochemical changes in wheat plants, including the accumulation of Reactive Oxygen Species (ROS), alterations in membrane stability and changes in protein expression. The overproduction of ROS under heat stress causes oxidative damage to cellular structures, including lipids, proteins and nucleic acids. Wheat plants activate antioxidant defense mechanisms to mitigate this damage, but the efficiency of these systems can be overwhelmed under severe stress conditions. Superoxide radicals, hydroxyl radicals and hydrogen peroxide are examples of ROS that are naturally formed in cells, but excessive amounts of these substances can be hazardous [27]. ROS are produced and accumulate as a result of heat stress [27-30]. Thus, antioxidant systems' detoxification of plants is significant for shielding them from heat stress [31,32]. Plants have both enzymatic and non-enzymatic antioxidant mechanisms as part of their antioxidant defense system. Ascorbate peroxidase, dehydroascorbate reductase, glutathione S-transferase, superoxide dismutase, catalase, guaiacol peroxidase and glutathione reductase are the components of the enzymatic antioxidant system [33]. Tocopherols, ascorbate and glutathione are examples of non-enzymatic antioxidants. High temperatures disrupt the lipid composition of cell membranes, leading to increased permeability and leakage of cellular contents. Membrane stability is a significant factor determining the extent of heat stress tolerance in wheat. Wheat plants produce Heat Shock Proteins (HSPs) in response to elevated temperatures. These proteins play a significant role in protecting cellular components from heat-induced damage and maintaining protein homeostasis. The chemical reaction to heat stress that has been investigated the most is the expression of HSPs. HSPs prevent heat-induced protein aggregation, which allows proteins to refold during the recovery phase [34-37]. According to Coles et al., the two most important factors influencing wheat grain quality are grain size and protein concentration [38]. Heat stress during the grain-filling phase reduces the amount of starch deposited in the grain, which increases protein concentration by permitting more nitrogen per unit of starch [39]. These findings have been reported by Wardlaw et al., and Gooding et al., [40 41]. A basic reaction to heat stress is the expression of HSP genes [42]. Wheat experiences a decrease in normal protein synthesis when exposed to high temperatures (>35°C), although HSPs are still generated [43].

Yield-related impact

Heat stress during significant growth stages such as anthesis and grain filling can lead to significant yield reductions. Heat stress can reduce the number of grains per spike and the individual grain weight, resulting in lower overall yield. High temperatures during the grain filling period accelerate the senescence process, limiting the duration of grain filling and reducing final grain size. Increased temperature affects both grain weight and number [44]. The developmental stage at which the elevated temperature occurs determines how temperature affects each of these grain yield components. For example, temperatures exceeding 20°C between spike initiation and anthesis may significantly limit the quantity of grains per spike [45]. Heat stress speeds up development of the spike reducing spikelet number and thus, the number of grains per spike [46]. The time between the onset of the spike and anthesis is not the most vulnerable to heat stress, though. The window of time between the emergence of double ridges on the flag leaf and shoot apex is the most important. During this time, an inverse relationship has been discovered between the number of grains per spike and the duration of heat stress [47]. This sensitivity is caused by spikelets that start to emerge in the spike-known as the double ridge stage-from tissue ridges between ridges of undifferentiated leaf primordia. Then, floret production begins on each spikelet meristem. Both the number of spikelets per spike and the number of grains per spikelet decrease with a reduction in the time between emergence and double ridge and anthesis [48]. The quality of wheat grain, including protein content and gluten strength, is also compromised under heat stress. For protein composition, high temperature stress reduces the glutenin/gliadin ratio and limits the synthesis of the larger Sodium Dodecyl Sulfate (SDS)-insoluble glutenin polymers which causes wheat dough to have weaker viscoelasticity properties [49].

DISCUSSION

According to McClung et al., heat stress interferes with a number of plant functions, causing morpho-physiological changes in wheat plants that impede their growth and ultimately result in a significant loss of production [50]. The way that plants react to heat stress varies greatly depending on the temperature, its length and the stage of growth that is being affected. Depending on the crop species, photosynthetic activities may withstand heat stress more readily and are rather stable between 30°C and 35°C. However, when temperatures rise above 40°C, photosynthesis is negatively impacted. Elevated temperatures cause O_2 and CO_2 to become less soluble; conversely, a higher concentration of CO_2 than O_2 leads to greater photorespiration and reduced photosynthesis [51]. Activities at Ribulose Bisphosphate Carboxylase Oxygenase (RUBISCO) break down in hot weather [52]. Reduced photosynthetic capacity under heat stress [53]. A significant part of leaf photosynthesis is played by photosystem II, one of the photosynthetic apparatus's components that is comparatively more resistant to heat stress than drought [54]. Furthermore, it is thought that mitochondrial respiration plays a significant role in determining a plant's ability to develop and survive [55]. Wheat morphology and seed germination are adversely affected by heat stress [56]. The symptoms of heat stress include decreased root diameter, length and quantity of roots. Because there is less carbon partitioning to the roots under heat stress during reproductive development, root growth is similarly slowed down [57]. The ideal temperature range for root growth is extremely limited when compared to other growth processes [58].

Heat stress causes fewer grains to form, which lowers the wheat harvest index [59]. The impact of heat stress on grain size and quantity however, differs depending on the developmental phases that are affected. For example, temperatures over 20°C during the period between spike initiation and anthesis accelerate spike development but decrease the amount of grains and spikelets per spike [60]. Male sterility results from heat stress's detrimental effects on pollen cells and microspores [61]. Depending on the genotype, wheat can become completely sterile even at temperatures exceeding 30°C during floret development [62]. According to Hedhly et al., wheat anther generated under three days of heat stress during anthesis was discovered to be physically aberrant and non-functional florets [63]. A daytime high temperature of 31°C/20°C may also result in grain shrinkage because of modifications to the endosperm and aleurone layer's structural makeup [64].

High temperatures have a significant impact on the wheat grain filling stage. According to Dias et al., heat stress typically shortens the grain filling time and speeds up the rate of grain filling [64]. However, in plants with varying grain weight stability, the rate and length of grain growth reduced [65]. Grain filling time in wheat can be shortened by 12 days for every 5°C increase in temperature above 20°C [66]. Compared to daytime temperature, an increase in night time temperature is more sensitive, shortens the grain filling period and lowers the grain yield. A reduction of 3 to 7 days was seen in the grain filling period by night time temperatures of 20°C to 23°C [67]. The rate of grain filling in wheat cultivars under day/night temperatures of 32°C/22°C was found to be significantly lower recently than at 25°C/15°C. Many cereals and legumes are affected by heat stress in terms of grain quality, primarily

due to reduced nutrient remobilization and assimilation [68]. According to Lizana et al., heat stress has no effect on the protein concentration of wheat grain; nevertheless, Iqbal et al., found a significant link between leaf nitrogen content and grain protein [69,70].

CONCLUSION

Heat stress poses a significant challenge to wheat production in the semi-arid region of Rajasthan. Understanding the physiological responses, biochemical responses and yield related responses of wheat to heat stress is essential for developing effective mitigation strategies. The frequency of high temperatures that stress wheat is predicted to rise globally. Grain setting, length and rate are all significantly impacted by heat stress, which eventually lowers grain yield. However, the influence of heat stress on grain yield depends on its timing, duration and intensity. To address these challenges, there is a pressing need for the development of heat-tolerant wheat cultivars. Advancing our understanding of how wheat responds to elevated temperatures and enhancing its tolerance through genetic and agronomic innovations are essential steps toward ensuring sustainable wheat production. In the face of climate change, these efforts are critical to maintaining food security and supporting the livelihoods of millions, particularly in regions like Rajasthan where wheat is an important crop.

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REVIEW ARTICLE

A review: Nutritional value of winter vegetables

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Winter vegetables are a significant part of a healthy diet, providing essential vitamins, minerals and antioxidants that support various health aspects. These vegetables, particularly grown in colder climates are rich in vitamins, minerals, fiber and antioxidants that contribute to overall wellness. Vitamins like vitamin A, vitamin B, vitamin C and vitamin K are essential for vision, immune function and skin health. Minerals like potassium, magnesium and iron are essential for various physiological functions. Leafy greens, cole crops, bulb crops and root vegetables are rich in antioxidants and phytochemicals that protect cells from oxidative stress and inflammation. Regular consumption of these vegetables can reduce the risk of chronic diseases and improve dietary patterns, food security and human health. Winter vegetables, particularly leafy greens and root vegetables, are a staple food with significant nutritional qualities that contribute to overall health.

Key Words: *Winter vegetables; Vitamins; Minerals; Antioxidant; Human health*

INTRODUCTION

India is the world's second-largest producer of vegetables, using 10.1 million hectares of land and producing 209.14 million tons of vegetables year. Hardy and nutrient-dense, winter vegetables flourish in colder climes and provide essential nutrients during the cold months. Vegetables are a key component of a diet that is nutrient-rich and well-balanced since they provide so many essential elements that promote overall health and wellness. Rich in vitamins, minerals, fiber and antioxidants, vegetables are vital for maintaining good health and preventing chronic ailments. Vegetables are the most accessible and reasonably priced sources of essential fibers, vitamins, minerals, essential amino acids and chemicals that are notably helpful in preventing illness [1]. Winter vegetables, a staple food have significant nutritional qualities that contribute to overall health [2]. In this in-depth analysis, we will look at the diverse array of nutrients found in vegetables, shedding light on their individual benefits as well as their collective impacts on human health. Vegetables are an excellent source of several vitamins, each of which plays a unique role in maintaining health. Vitamin A is essential for healthy skin, strong immune and clear vision. Good sources of this vitamin include spinach, carrots and sweet potatoes. Rich in antioxidants, vitamin C boosts immunity and encourages the production of collagen. Broccoli, bell peppers and citrus fruits all have high concentrations of it. For strong bones and proper blood coagulation, vitamin K is essential. Dark green vegetables such as Swiss chard and kale are excellent sources of this vitamin.

Minerals are abundant in vegetables and are essential for many physiological functions. Leafy greens high in iron, such as kale and spinach, support the blood's oxygen transport mechanism. Bananas, sweet potatoes and tomatoes are high in potassium, which is necessary to maintain normal blood pressure. Magnesium is abundant in green leafy vegetables like spinach and Swiss chard and is essential for strong muscles and neurons. Vegetables, being high in dietary fiber, aid in maintaining a healthy digestive system and prevent conditions such as constipation. Fiber also helps with weight control by increasing satiety and reducing total calorie intake. Broccoli, brussels sprouts and peas are examples of vegetables high in fiber that improve digestive health and overall well-being. Vegetables are rich in antioxidants and phytochemicals, which protect cells from oxidative stress and inflammation. Tomatoes contain lycopene, a powerful antioxidant that has been connected to a decreased risk of numerous cancers. Among the cruciferous veggies are cauliflower and broccoli. Both plants contain the anti-cancer substance sulforaphane. Flavonoids, which have anti-inflammatory and heart-protective qualities are found in citrus fruits and onions. Leafy greens, such as Swiss chard, kale and spinach, stand out as foods that are very high in nutrients. Vitamins A, C and K, as well as calcium and iron, are all abundant in these greens. When incorporated into the diet, these nutrient-dense greens may provide a multitude of essential nutrients and enhance overall health. cruciferous vegetables, such as brussels sprouts, cabbage and broccoli, provide a number of health benefits. Among these are compounds like as glucosinolates, which have been linked to a lower risk of cancer. These vegetables are also a fantastic source of fiber, vitamins and minerals that support cardiovascular health and the body's detoxification procedures. A diet high in vegetables has been associated with a lower risk of cardiovascular disease in people [3]. Root vegetables high in nutrients, such as carrots, sweet potatoes and beets are also delicious. Sweet potatoes provide a good dose of fiber, vitamins and minerals and carrots being abundant in beta-carotene, aid in eye health maintenance. Beet nitrates have the potential to improve athletic performance by increasing blood flow. Daily vegetable consumption has been clearly associated with better gastrointestinal health, reduced risk of heart disease, stroke, anemia and other disorders [4]. Allium vegetables, such as garlic, onions and leeks are well-known for their distinct flavors and potential health benefits. Garlic in particular has been associated with cardiovascular health since it may lower blood pressure and cholesterol. Onions contain a flavonoid called quercetin, which is anti-inflammatory and antioxidant. The vibrant colors of vegetables sometimes indicate the availability of certain nutrients. Strong skin and a healthy immune system are supported by vitamin C and carotenoids, which are found in abundance in red and orange foods like tomatoes and bell peppers. Purple foods like eggplant and purple cabbage contain compounds called anthocyanins, which have antioxidant and anti-inflammatory properties. Eating a variety of veggies on a regular basis has been linked to a lower risk of acquiring chronic conditions including diabetes, heart disease and various cancers. We explore the many facets of winter vegetables in this social science investigation, looking at their nutritional value and wider societal ramifications. We examine the effects of winter vegetable intake on dietary patterns, food security and community health *via* a social lens. We want to understand the complex relationships between winter vegetables and social well-being through an examination of cultural norms, economic variables and access to nutrient-dense foods.

LITERATURE REVIEW

Nutrients contain in winter vegetables

Lettuce: Lettuce is a leafy green that is high in nutrients. It has the vitamins A, K and C as well as fiber and folate. Because it is low in calories and carbs, it aids with blood sugar balance and weight control. A vital component of a balanced diet, lettuce adds crunch and freshness to salads and wraps and is very adaptable. Lettuce is high in flavonoids, tocopherols and conjugated quercetin. Crozier et al., similarly reported significant variations in flavonol

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concentrations between lettuce cultivars [5]. The popular tiny "round" lettuce was found to have a quercetin concentration of just 11 µg/g fresh weight, while "iceberg" lettuce had a far lower quercetin content. Conversely, the red lettuce cultivar "Lollo Rosso" had 911 µg/g on its outer leaves. Like quercetin, this lettuce's high anthocyanin concentration is a consequence of the phenylpropanoid pathway. This is why the lettuce looks red. Larger concentrations of related compounds, such flavonols, may also be present given the increase of one pathway end-product.

Green peas: While you may eat peas all year round, winter is the best time to eat fresh green peas. Peas are another key food, they are rich in fiber and antioxidants which help prevent gastrointestinal problems and they are excellent sources of plant-based protein. The fact that peas are easy to include into most Indian cuisines is another benefit. Peas have high amounts of vitamins A and B in them. Uncooked peas can also be eaten and doing so has no detrimental health consequences [6]. One excellent source of iron is legumes. In 2010, Trinidad et al., conducted an *in vitro* study on the mineral availability of iron, zinc and calcium in ten native legumes (cowpeas, mung beans, pole sitao, chickpeas, green peas, groundnuts, pigeon peas, kidney beans, lima beans and soyabeans) [7]. Peas, lentils and leafy vegetables are good sources of protein [8].

Cole crops: Cole crops are one of the largest groups of temperate vegetables; this group includes important crops such as brussels sprouts, broccoli, cauliflower and cabbage. Cole crops are rich in vitamin C and a great source of minerals. Many volatile sulfur compounds are the source of cole crops unique taste. It has been proposed that dimethyl trisulfide has a major role in the taste of cooked brassy vegetables. A particularly nice aroma comes from cabbage because to the synigrin glucoside. It's loaded in nutrients. It has high levels of vitamins "A" and "C" and minerals like calcium and phosphorus. It is a vegetable and is used in salads dried and pickled to preserve. The experiment conducted by Hansen et al., revealed a noteworthy variation in the concentration of specific glucose-nolate across the 21 red cabbage cultivars and 6 white cabbage cultivars examined [9]. It was shown that red cabbage cultivars have much higher quantities of glucoraphanin than white cabbage cultivars. The red cabbage types also showed notable differences. "Rodima" exhibited the highest glucoraphanin concentration (7.4 mg/g DW) of the red cultivars examined, while "Primero" had the lowest value (0.6 mg/g DW). When comparing the glucoiberin concentrations of the white and red cabbage cultivars, the white cultivars are much higher. The white cabbage cultivar "Bartolo" had the greatest quantity at 7.4 mg/g dry weight, while the cultivar "Candela" had the lowest amount at 1.7 mg/g dry weight. The red cultivars ranged in dry weight from around 3 mg/g to 0.3 mg/g. Furthermore, it was shown that red cabbages had a substantially higher amount of gluconasturtiin than white cabbage cultivars. The cultivar "Amager Garo" had the greatest content, while the cultivar "Primero" had the lowest, with 1 and 0.1 mg/g dry weight, respectively. In addition to having enough quantities of vitamin B, lump cabbage is rich in minerals and has more protein than other vegetables. Both vitamins "A" and "C" and minerals like calcium and phosphorus are abundant in it. Broccoli is nutrient-rich, consuming one or more servings of broccoli per week has been shown to reduce the incidence of prostate cancer and delay the disease's transition from a localized to an aggressive form [10,11]. Broccoli-rich diets may also reduce the risk of prostate cancer. Brussels sprouts are an extremely nutrient-dense veggie. Appropriate levels of protein, calcium, iron and vitamin A are present. In terms of vitamin content, brussels sprouts and broccoli were evaluated comparably well by Kurlich et al., with high amounts of C and E as well as β-carotene [12]. Known as the Cruciferae or Brassicacea family, cruciferous vegetables include mustards, watercress, cabbage, broccoli, cauliflower, brussels sprouts, kales, kailan, Chinese cabbage, turnip, rutabaga, radish, horseradish and rocket. These vegetables also contain the highest concentrations of glucose-olates in the human diet. The majority of consumers believe that eating a diet high in vegetables is healthy. This is because, in 1997 the World Cancer Research Fund in the United States concluded that, when paired with vegetables high in other phytonutriceuticals, cruciferous diets are likely to protect humans against cancers of the thyroid, colon and rectum in addition to potentially preventing cancers of other organs. Based on one of the biggest and most comprehensive examinations of food and cancer, this conclusion was reached. It has been shown that cruciferous vegetables strong in glucose-nolates, such as broccoli, cabbage, brussels sprouts, kale and others, provide protection against cancers of the lung, prostate, breast and other organs affected by chemicals [11]. Substantial variations were seen between and among these crucifers when the levels of α- and β-, α- and γ-tocopherols as well as vitamin C were assessed in broccoli, brussels sprouts, cabbage, cauliflower, tronchuda and kale [13]. Vitamin C is the most common vitamin among the five crucifers that were investigated. Kale had the highest concentration of these vitamins, with broccoli, cauliflower, cabbage and brussels sprouts following closely after. Genetic factors were shown to account for 79% of the variability in broccoli's β-carotene, 82% of its α-tocopherol and 55% of its vitamin C levels [12]. Crucifers are also an excellent source of folate. Approximately 110-135 and 70-90 µg/100 g, respectively, were found to be among the best vegetable sources of folate, according to research by Scott et al., and Konings et al., [14,15]. Broccoli stores selenium as selenocysteine, which is readily absorbed by human tissue [16]. Selenium-supplemented broccoli has been demonstrated to reduce colon cancer and breast cancers in animal models [17]. According to Kumar et al., the cabbage family of vegetables, which includes cabbage, cauliflower and brussels sprouts has compounds that may help prevent cancer [1].

Onion and garlic: Onions and garlic are not only delicious side dishes, but they are also very nourishing. Both vegetables are low in calories but high in essential nutrients. Onions for instance, are a great source of vitamin C, an antioxidant that supports strong immunity and beautiful skin. Quercetin is another antioxidant that has anti-inflammatory properties. In addition, onions include fiber, potassium and folate, which are essential nutrients for overall well-being, including heart and digestive health. The highest total flavonoid content was found in onion leaves, out of the 62 vegetables that Miean et al., examined [18]. The total flavonoid concentrations of garlic and onion leaves were around 1.0 and 2.7 g/kg dry weight, respectively. Onion leaves contain around 55% quercetin, 31% kaempferol and 14% luteolin as flavonoids. About 95% of the flavonoids in onion bulbs are quercetin; kaempferol is only trace levels [19]. Research indicates that white onion cultivars have a significantly lower quercetin concentration than red onion cultivars, with the bulk of quercetin concentrated in the outer scales. Red onions contained approximately 1350 µg/g of total flavonols, whereas white onions had just around 10 µg/g. According to Herrmann, quercetin primarily appeared as a free-form aglycone in onions [20]. Garlic has some of these nutritional benefits and also has high levels of fiber and vitamin C. One of the most well-known components of garlic is allicin, a sulfur-containing compound that also provides garlic its distinct aroma and certain health advantages. Garlic may have more cardiovascular benefits if allicin lowers blood pressure and cholesterol. It is also believed to possess antimicrobial qualities that aid in the prevention of illnesses. Of the flavonoids in garlic cloves, myricetin makes about 72%, apigenin 23% and quercetin 5% [18]. Several epidemiological studies show that the use of alliums, such onions and garlic and the occurrence of cancer are inversely correlated. A synthesis of case control studies carried out in Italy and Switzerland found that consuming one to seven servings of fish a week reduced the incidence of cancers of the mouth, throat, colon and ovaries [21]. Furthermore, a range of bioactive chemicals found in onions may reduce the occurrence of cardiovascular diseases. A human trial found that consuming the equivalent of three onions in a soup was sufficient to significantly reduce the aggregation of blood platelets [22].

Carrot: Carrots are another vegetable that is generally available throughout the winter. It's a great way to get vitamins and minerals. Carrots can cause shortages in vitamins A, B and C. In addition to other minerals like folate, iron, copper, potassium and more carrots are a great source of important vitamins. Carrots provide several health benefits. Regular consumption improves eyesight, strengthens immunity and wards against cancer. Carrots contain three flavonoids that are uncommon in combination: kaempferol, quercetin and luteolin [23]. Over the course of the last forty years, carrots have experienced a tremendous increase in total carotenoid levels through conventional breeding, reaching 1000 ppm carotenoids on a fresh weight basis.

Radish: A common vegetable for salads and cookery is the radish. It's also eaten as a paratha with curd for breakfast and it tastes strong. Its leaves are often used to cook vegetables. Vitamin C and other minerals are abundant in radishes. Radish should also be avoided by those who have liver illness or jaundice. In addition to being high in fiber, they also include vitamins E, A, C, B6 and K, antioxidants, zinc, phosphorus, potassium, magnesium and calcium. The three primary glucosinolates identified in radish are glucoerucin, glucoraphanin and glucobrassicin [24].

Turnips: Turnips are another one of the greatest winter vegetable selections. One excellent source of vitamin C is turnip greens. It improves lung health

by lowering lung inflammation and emphysema. Turnip consumption also has the added benefit of occasionally treating kidney stones. Eating turnips every day can assist with the problem if you don't have significant stone growth [6].

Beetroot: Beetroot holds a significant position among root vegetables. There are several reasons beets are farmed. Usually, it's used in salads and beverages. The body uses it to make up for its blood deficiency. Magnesium, calcium, potassium, phosphorus, iodine, iron, manganese and vitamins A, C, B1 and B2 are all present in large amounts. They boost immunity since they are high in vitamin C. They really benefit the skin and hair.

Fenugreek: Botany classifies this crop as an annual herbaceous plant that is grown for its seeds and leaves, both dried and fresh. Fenugreek is used in cosmetics, cuisine, medicine and animal feed. Its fresh, green and dried leaves are used as a vegetable in the winter because they are high in iron, sulfur, calcium, magnesium, oil, protein, fiber, carbohydrate and vitamins A, C and nicotine. Its seeds are used as a spice in pickles and vegetables. Fenugreek has a high nutritional content and is used in Ayurveda medicine to treat a variety of illnesses. Research indicates that individuals with diabetes, high cholesterol, diarrhea and dysentery benefit more from consuming seeds [6]. Fenugreek and other Indian green leafy vegetables are good sources of soluble dietary fiber, according to published studies. Consuming more vegetable fiber decreases the risk of cardiovascular diseases, supports a healthy body weight, aids in the maintenance of a healthy digestive system and may even prevent colon cancer [25,26].

Spinach: Being abundant in vitamins and low in calories, spinach is one of the healthiest foods out there. It is one of the foods with the most nutrients. It is a great source of vitamins A and C as well as foliate. Sa'eed et al., claim that heat causes a green's oxalate content to decrease, releasing calcium for the food [27]. While raw spinach is still delicious in salads, cooked spinach has more benefits. These are composed of antioxidants and phenolic compounds, which are secondary metabolites of beneficial plants [1]. Spinach is one of the green veggies that is most often served in Indian families. Spinach is a highly healthy leafy green that may be eaten and helps with many different types of ailments. It also compensates for the deficiency of many vitamin types. Spinach is something you should eat every day. Among the green crops cultivated in India, spinach has a prominent place. Spinach is a crop that is rich in vitamins, minerals and iron. It is used as a green vegetable. While calcium (vitamin A) is plentiful, iron phosphorus (vitamin C) is found in low amounts. Asthma, cancer, stones and scabies may all be avoided with spinach leaves. Because it is antipyretic, blood purifying, healthy and lowers blood pressure, this coolant is great for those with high blood pressure. Lastly, spinach promotes the development of strong hair and skin. Spinach is one of the foods high in fiber [25]. According to studies found in the literature, spinach has a high soluble fiber content. Like other leafy green vegetables, spinach is an excellent source of nutrients. A half-cup of boiled spinach provides 573 micrograms (mcg) of vitamin A or 229% of the recommended daily intake. Some research suggests that spinach might strengthen the heart and lower blood pressure. Fresh for instance, spinach has the highest quantities of calcium (1036 mg/100 g), magnesium (827 mg/100 g), iron (28.4 mg/100 g) and salt (827 mg/100 g). Spinach is a great example of a meal that has relatively high calcium content but that the body can scarcely absorb due to its high oxalate concentration. Even though it is technically correct, marketing spinach as a food high in calcium is deceptive because it is not a very good source of calcium for humans [28].

DISCUSSION

Winter vegetables, are a vital part of a healthy diet, providing essential vitamins, minerals and antioxidants that support various health aspects. These vegetables, especially those grown in colder climates, are rich in vitamins, minerals, fiber and antioxidants that contribute to overall wellness. Vitamins like vitamin A, vitamin B, vitamin C and vitamin K are essential for vision, immune function and skin health, while minerals like potassium, magnesium and iron are essential for physiological functions. Regular consumption of these vegetables can reduce the risk of chronic diseases and improve dietary patterns, food security and human health. Their antioxidant content protects cells from oxidative stress and inflammation, making them a vital part of a balanced diet. Winter vegetables play an important role in maintaining a healthy diet during the colder months, offering an array of essential nutrients that support overall well-being. These vegetables are not only versatile in their culinary uses but also packed with vitamins, minerals and antioxidants that help the body thrive in winter. Carrots are a staple winter vegetable, celebrated for their high beta-carotene content, which the body converts into vitamin A. This nutrient is essential for maintaining healthy vision, supporting immune function and promoting skin health. Additionally, carrots are a good source of dietary fiber, which aids digestion and contributes to gut health. The potassium in carrots also helps regulate blood pressure, making them a well-rounded vegetable for winter nutrition [23].

Spinach is another nutrient-dense winter green, rich in iron, calcium, magnesium and vitamins K, A and folate. The high iron content in spinach is particularly important for red blood cell production, helping to prevent anemia and maintain energy levels during the winter. The calcium and vitamin K in spinach are vital for bone health, while its magnesium content supports muscle and nerve function. Spinach's versatility makes it an excellent addition to a variety of dishes, ensuring that these nutrients are readily available in the diet. Broccoli, a member of the cruciferous vegetable family, is packed with vitamin C, vitamin K, folate, fiber and powerful antioxidants like sulforaphane. Vitamin C is particularly important during the winter months, as it boosts the immune system, helping to ward off colds and other illnesses. The fiber in broccoli aids digestion and supports gut health, while its antioxidants may have cancer-preventive properties, making broccoli a valuable component of a winter diet. Brussels sprouts, another cruciferous vegetable, are rich in fiber, vitamin C, vitamin K and folate. These nutrients contribute to heart health, promote healthy skin and have anti-inflammatory properties. The high fiber content of brussels sprouts supports digestive health and helps maintain a healthy weight by promoting a feeling of fullness. Kale is often touted as a superfood and for good reason. It is exceptionally rich in vitamin K, vitamin C, vitamin A, fiber and antioxidants. These nutrients support a wide range of bodily functions, from bone health to immune function. Kale's high antioxidant content helps combat oxidative stress, which can damage cells and lead to chronic diseases. Incorporating kale into winter meals can provide a significant nutritional boost. Sweet potatoes are another winter favorite, known for their high beta-carotene content, which, like carrots, supports skin health, vision and immune function. They are also rich in vitamin C, potassium and fiber, making them a great source of energy and a valuable addition to a balanced diet. The potassium in sweet potatoes helps regulate blood pressure, while their fiber content aids digestion. Cabbage is a versatile winter vegetable that is high in vitamin C, vitamin K, folate and fiber. It supports digestive health, aids in detoxification and has anti-inflammatory properties. Cabbage is also known for its heart-health benefits, making it a great choice for winter meals.

CONCLUSION

In conclusion, winter vegetables are essential for a balanced diet, providing a diverse array of nutrients that support overall health and wellness. These hardy vegetables, flourishing in colder climates, are rich in essential vitamins like A, C and K and minerals such as potassium, magnesium and iron. Their high antioxidant content helps combat oxidative stress and inflammation, reducing the risk of chronic diseases. Leafy greens like spinach and kale, cruciferous vegetables such as broccoli and brussels sprouts and root vegetables like carrots and sweet potatoes, all contribute to improved immune function, digestive health and cardiovascular wellness. By incorporating these nutrient-dense vegetables into daily meals, individuals can enhance their health, bolster their immune systems and support long-term well-being during the winter months. Their versatility and rich nutritional profiles make winter vegetables a valuable staple in maintaining a healthy and balanced diet.

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REVIEW ARTICLE

Impact of mass media in agriculture: An overview

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Mass media significantly impacts the agricultural sector, influencing information dissemination, community building and sustainable farming practices. It provides farmers with real-time updates on weather forecasts, market trends and agricultural practices, enabling them to optimize their operations and improve yields. Mass media also serves as an educational tool, raising awareness about sustainable farming practices and environmental conservation. Documentaries, educational programs and articles inform farmers about biodiversity, soil health and water conservation. By promoting sustainable practices, mass media encourages farmers to adopt methods that enhance productivity while protecting the environment. This educational aspect is significant in encouraging a responsible approach to agriculture, ensuring sustainable practices for future generations. The impact of mass media on agriculture is multifaceted, enhancing communication, education and community engagement. As technology evolves, the influence of mass media in agriculture will likely expand, providing more opportunities for farmers to thrive in an ever-changing landscape.

Key Words: *Mass media; Information; Sustainable farming; Farmers; Agriculture*

INTRODUCTION

Mass media plays a pivotal role in the agricultural sector, serving as a vital conduit for information dissemination, education and advocacy. Its influence is far-reaching, impacting the decisions, practices and overall development of agriculture worldwide. In emerging nations, the majority of people still rely on "traditional mass media" including radio, television and newspapers. Accordingly, these three media outlets could be useful for spreading agricultural-related information [1]. Educating the public about new government initiatives, methods and technology is one of the main roles of mass media in agriculture. Numerous media platforms such as radio, television, advertising, movies, the internet, newspapers, magazines and so on are among the technologies used in this communication [2]. Mass media is important in helping farmers receive developments in contemporary agriculture [3]. Furthermore, by drawing attention to certain concerns, the media can improve people's understanding and alter their behavior [4,5]. Newspapers provide additional benefits, such as stable form a wealth of information and authority, even if radio and television are the mass media formats with the quickest rates of growth [6]. Additionally, the media serves as a link between farmers and resources and markets. It offers vital details on demand patterns, market pricing and the most effective ways to promote agricultural goods. This relationship aids farmers in making wise choices and maximizing their earnings. Furthermore, media outlets provide farmers with access to professional viewpoints, guidance and solutions to issues in agriculture, helping them to address obstacles more skillfully. The media is very important for lobbying and influencing policy. Through drawing attention to problems that farmers confront, such the effects of climate change, water shortages and financial restrictions the media may persuade decision-makers to take these issues seriously. By advocating for farmers, we can make sure that their needs are met and that their voices are heard. On the other hand, the media also supports government programs and policies meant to assist farmers and make sure they are aware of the advantages that are accessible to them. In several nations, grower communities decision-making and the progress of agriculture and rural areas have benefited from the usage of Information and Communication Technologies (ICTs) [7-9].

Through new technologies that are unique to producers, ICTs have significantly changed agricultural improvement and relocation skills and knowledge [10]. In addition to the potential for ICT to disseminate agriculturally efficient information among producer's other media such as radio, television, mobile phones and the internet can also facilitate the exchange of pertinent and appropriate materials that promote the efficient and productive use of resources [11,12]. The integration of technology with mass media has further revolutionized agricultural communication. Digital media including social media platforms, mobile apps and websites offer real-time updates and interactive platforms for farmers to engage with experts and peers. This technological integration has made information more accessible and timely, allowing farmers to adapt quickly to changing conditions. However, traditional media such as television and radio still play a significant role particularly in rural areas where access to digital technology may be limited. Programs customized to local languages and cultures enhance understanding and adoption among diverse audiences.

LITERATURE REVIEW

Mass media plays a significant role in the dissemination of agricultural information, influencing the practices, decisions and overall development of the agricultural sector. Here's a review of the role of mass media in agriculture:

Information dissemination

Awareness creation: Mass media helps raise awareness about new agricultural technologies, practices and government schemes. It reaches a wide audience, ensuring that farmers are informed about innovations that can enhance productivity.

Education and training: Educational programs broadcasted through radio, television and online platforms provide farmers with knowledge about improved farming techniques, pest management and sustainable practices.

Advocacy and policy influence

Highlighting issues: Media can bring attention to challenges faced by farmers, such as climate change impacts, water scarcity and financial issues, influencing policymakers to address these concerns.

Promoting policies: Government policies and initiatives aimed at supporting farmers are communicated through mass media, ensuring that farmers are aware of the benefits available to them.

Technological integration

Digital media: The rise of digital media and mobile technology has revolutionized the way agricultural information is shared. Social media platforms, mobile apps and websites offer real-time updates and interactive platforms for farmers to engage with experts and peers.

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Television and radio: Traditional media still play a significant role in rural areas where access to digital technology may be limited. Programs customized to local languages and cultures enhance understanding and adoption.

Behavioral change and adoption

Influencing attitudes: Media campaigns can change perceptions and attitudes towards certain agricultural practices, encouraging the adoption of environmentally friendly and economically beneficial methods.

Success stories: Sharing success stories and testimonials of farmers who have benefited from adopting new technologies or practices can motivate others to follow suit.

Challenges and limitations

Access and literacy: Not all farmers have access to mass media or the literacy level required to fully benefit from the information provided.

Content relevance: Information must be relevant and customized to local contexts to be effective. Generic content may not address specific regional agricultural challenges.

Use of newspaper in agriculture

Newspapers are important for providing the public with vital information, but there are still worries around the world that they will prioritize political, entertainment and advertising over development issues like agriculture [13]. According to a Nigerian survey, newspapers don't focus much on agriculture. 36 out of 750 agriculture news stories (4.8%) were featured on the first page. Oladele reported that public media in Botswana cover agricultural news less frequently than private publications. Newspapers typically don't provide a lot of information on agriculture [14]. According to Rolle et al., there are other means to get the most recent information on agriculture outside of periodicals, newspapers and pamphlets such as electronic media, television, mobile phones and radio [15].

Use of radio in agriculture

Radio has been a significant tool in agriculture, providing farmers with vital information and support, especially in rural and remote areas. Its widespread reach, accessibility and ability to deliver timely information make it an effective medium for agricultural communication. Radio plays a vital role in the dissemination of critical information, including market pricing and weather predictions, which is one of its main advantages. Farmers may make better marketing decisions and increase profitability by using market pricing information, which they can use in conjunction with timely weather updates to assist them prepare for planting, harvesting and other operations. The study was concluded by Okwu et al., and it is evident that radio and agricultural initiatives are effective [16]. The majority of farmers like taking part in agricultural programs, according to the statistics which suggests that most producers tune in to radio programs about plants and agronomic items. Moreover, some farmers like hearing about cattle expertise. Radio transmission is still widely used by farmers in rural areas. A lot of farmers rely on radio and newspapers. According to Zhang et al., these broadcast networks have the potential to enhance agricultural development skills and knowledge while serving as a vital conduit for critical information among rural producers [17].

In India's rural agricultural markets, where there isn't a consistent and reliable electricity supply in remote and rural locations, it serves as a potent communication tool. The radio is the only source of information, entertainment and education that people can rely on. For instance, All India Radio (AIR) operates a number of radio stations under the "Kisanvani" concept. The goal is to provide local farmers with up-to-date information regarding weather reports, daily market pricing and other micro-level details in their individual areas. Kisanvani is currently broadcast from 96 AIR stations located all across the nation. "Kisanvani, Samruddhi, Krishi jagat and Suno kisan" is one of the several programs [18].

Use of television in agriculture

Television has become an indispensable tool in the field of agriculture, playing a pivotal role in disseminating information, providing education and encouraging community engagement among farmers. With its unique ability to deliver both visual and auditory content, television offers a powerful medium for conveying complex information in a manner that is both engaging and easy to understand. Because of its influence and scope, it has proven to be a useful instrument for promoting innovations and sustainable farming methods. Without a doubt, television cannot provide the most recent agricultural facts. The findings demonstrate that television is a useful medium for distributing current information, such as news or the greatest knowledge available on wheat, seeds and soil [19]. Television has been a vital tool for spreading the most accurate information about the agriculture industry in Ethiopia and India. It has been noted that agricultural farmers may readily receive improved information by viewing television programs related to farming [20]. All members of society may obtain knowledge and skills *via* television, which also helps farmers become more knowledgeable about the use of new technology in agriculture and transmits content that grabs viewer's interest. Also a lot of people rely on the media to provide them with the most recent information on health, education and agriculture [21]. It is observed that many developing nations have set up a number of communication hubs to spread the word to farmers about the benefits of agriculture. Nonetheless, governments have established agricultural information clearinghouses in several nations. Moreover, producers in developing nations can obtain the most agricultural knowledge *via* television [22]. Television directors and producers will devise new strategies for agricultural growth in order to generate ideas for agricultural development from the standpoint of rural and agricultural progress [21].

Use of social media in agriculture

Social media has become an invaluable tool in agriculture, transforming how farmers connect, share information and promote their products. Platforms like facebook, twitter, instagram and linkedin allow farmers to engage with a broader audience, including consumers, suppliers and industry experts. Farmers may promote a favorable image of agriculture by using social media to highlight sustainable agricultural methods, share success stories and highlight their practices. Social media is the term for digital devices that are mostly based on the internet and are used by individuals to share and discuss data. It makes reference to knowledge, opinions and digital networks allow for the sharing and discussion of multimedia, music and video. Social media components that make them indispensable and accessible. Easy tools exist to enhance verbal communication gain access *via* mass non-public, mass self and mass mobile phone communications. an extensive network of weak links to ensure the receipt of new ideas. In essence, new media is all about what is popular and viral and the most popular platforms these days are youtube, facebook and instagram as they are easily available to anyone. In a research by Thakur et al., social media platforms used in agricultural communication activities were analytically tested [23]. The results showed that users preferred whatsapp over facebook because of its advantages over facebook, including ease, privacy and fewer data usage. Information quality, timeliness and accuracy will all increase as a result of social media technologies connecting the farming community with agricultural organizations. This promotes continuing communication with the agricultural community and the sharing of information in both directions. It also has several drawbacks, such a high frequency of pointless messages, excessive data use and spotty Internet access. According to Tamizhkumaran et al., youtube has a lot of potential for advising and extension services [24]. Client attention is drawn to graphics and videos that provide important information. Positive feedback may be obtained when extension agents respond to customer remarks, enabling two-way contact. State Agricultural University (SAU) and Krishi Vigyan Kendras (KVK's) can lead even the on-farm studies and front-line demonstrations to investigate the profitability of youtube. The use of social media by stakeholders in the agriculture industry is increasing. Professionals, researchers and other stakeholders in the agricultural sector are using social media at an increasing rate. Buying and selling of agricultural goods is made possible by the usage of internet media in the agricultural sector. Social media improves agriculture's marketing, education and communication while linking farmers with customers and the larger agricultural community. This allows farmers to innovate and adapt in a fast changing business.

DISCUSSION

Modern media

Impact of internet in agriculture: The use of the internet in agriculture has transformed the sector, enhancing productivity and efficiency. Farmers now have instant access to a wealth of information, allowing them to stay updated on best practices, pest management and crop health. Precision agriculture has emerged, utilizing sensors, drones and satellite imagery to monitor field

conditions. This data shared *via* the internet, enables informed decisions about irrigation and fertilization leading to increased yields. Moreover, the internet facilitates market access through e-commerce platforms, allowing farmers to sell directly to consumers and research market prices. As farmers communicate through social media and online forums to exchange experiences and seek advice, networking and collaboration have also improved. With the use of online learning resources and training materials, farmers may enhance their skills by using new methods and technologies. Indian gardeners are very internet literate. According to Luqman et al., growers are already using a range of websites to obtain essential information on how to apply pesticides in their agricultural areas in an appropriate manner [12]. The most important information on agriculture and other related topics may be found online completed the study, demonstrating that research on the internet may also be used to determine the function of intermediaries [12,17,25]. Although communities in Bangladesh's development network initiative lacked instant access to the internet, staff assisted them in identifying their requirements. Growers contact the Pallitathya Krishi Resource and Information Center (KRIC) with user questions *via* their phones. Operators use the internet system in tandem to reply to producers experiencing agricultural challenges and attempt to resolve their issues. According to current surveys, 94% of Malaysian producers utilize the internet to receive agricultural information, while 85% get the most recent information through text messaging. Furthermore, mail and internet servers as well as projects for grower's applications have been developed in India and the center gives farmers access to the most recent agricultural news. In remote locations, network services are connected using cable. The percentage of producers who lack literacy and knowledge of computer systems ranges from 85%-92%. Additionally, grower trainers have been chosen to instruct growers in order to transmit knowledge *via* the internet. In this scenario, farmers would not think twice to learn new information about using online resources and about markets and pesticides [4,26]. Additionally, farmers may sell directly to customers and investigate market pricing to the internet's e-commerce platforms, which make it easier to access markets. As farmers communicate through social media and online forums to exchange experiences and seek advice, networking and collaboration have also improved. Farmers may improve their abilities by adopting new technology and techniques with the help of online education and training tools.

Impact of mobile phone in agriculture: The use of mobile phones in agriculture has revolutionized farming practices, enhancing productivity and connectivity for farmers. With instant access to vital information, farmers can receive real-time updates on weather forecasts, market prices and pest management through Short Message Service (SMS) alerts and mobile applications. They may use this knowledge to make well-informed decisions on planting and harvesting. Additionally, mobile phones allow for direct contact between suppliers and customers, which lessens the need for middlemen and improves the negotiating position on prices. Farmers may also use mobile devices to receive advisory services from agricultural groups, which enables them to consult experts on sustainable methods and crop management. Another trial was finished in Ghana, where fruit producers were given smartphones to connect with buyers, sell their crops in advance, interact with consumers and get feedback. Growers may easily communicate with customers directly using smartphones and they receive greater evaluations directly from customers and agents. Smartphones also provide growers another advantage. They get in touch with them immediately and inquire about their agricultural output pace rather than visiting the market. Farmers stand to benefit financially, energetically and temporally from this [12,27,28]. Small farmers now have access to small business facilities and information about the market and weather in remote locations with smartphones. Growers that use cellphones to go with customers and offer their products at higher prices see a significant increase in productivity and revenue [19]. Reports state that producers now have a framework in place for disseminating and receiving updated information on agricultural productivity in cellphones. Many farmers currently use cellphones for many purposes and one of their uses is to get the market price for agricultural products. However, some openly communicate with clients in order to sell their commodities and products at premium rates. Moreover, producers use SMS systems to receive the most recent information about weather conditions and chemicals on their farms [19,29]. Without a doubt, cell phones were utilized in a variety of community sectors, including farming, health, education and rural development to support the economic advancement of developed countries. Mass media has the impact of empowering farmer's organizations in isolated locations and providing them with market knowledge. Additionally, producers reach out to consumers in a variety of urban marketplaces, selling their produce wherever they discover a competitive price [17,30]. Smartphones and other wireless devices were also used in the weather and climate monitoring system, which has greatly improved the income, level of awareness and acceptance in many areas. Additionally, these new services need to be familiarized with the agriculture sector so that producers may receive the most up-to-date techniques for modernizing their farming practices and advancing rural areas. Staff members have provided the newest wireless multi-hop for several features to interact with each other and handle issues with agricultural and rural development by using ICTs without experiencing any discomfort [31,32].

Mass media plays a significant role in shaping various sectors of society and agriculture is no exception. The influence of mass media on agriculture is extreme, affecting everything from information dissemination to community building. This overview explores the multifaceted impact of mass media on the agricultural sector, highlighting its significance in modern farming practices. One of the primary functions of mass media is the dissemination of information. In agriculture, timely access to information is vital for farmers to make informed decisions. Mass media channels, including television, radio, newspapers and online platforms, provide farmers with essential updates on weather forecasts, market trends and agricultural practices. For instance, farmers can learn about the best planting times, pest control methods and crop management techniques through agricultural programs and news segments. This access to real-time information helps farmers optimize their operations and improve yields. Mass media serves as an educational tool, raising awareness about sustainable farming practices and environmental conservation. Documentaries, educational programs and articles can inform farmers about the importance of biodiversity, soil health and water conservation. By promoting sustainable practices, mass media encourages farmers to adopt methods that not only enhance productivity but also protect the environment. This educational aspect is important in encouraging a more responsible approach to agriculture, ensuring that farming practices are sustainable for future generations. The impact of mass media on agriculture is significant and multifaceted. By enhancing communication, education and community engagement, mass media plays a vital role in modernizing the agricultural sector. As technology continues to evolve, the influence of mass media in agriculture will likely expand, providing even more opportunities for farmers to thrive in an ever-changing landscape.

CONCLUSION

In conclusion, mass media is an indispensable tool for transforming agriculture by providing essential information, encouraging innovation and advocating for policy changes. The agriculture industry is greatly impacted by mass media, which gives farmers chances to enhance their farming methods. With the help of its real-time updates on market trends, weather predictions and agricultural methods, farmers are able to increase yields and streamline their operations. The media may also be used as a teaching tool to promote environmental preservation and sustainable agricultural methods. A responsible approach to agriculture is promoted *via* documentaries, educational programs and publications that educate farmers about biodiversity, soil health and water conservation. Mass media's impact on agriculture will probably grow as technology develops, giving farmers more chances to prosper in a constantly shifting environment. All things considered the mass media is extremely important in influencing many facets of society, including agriculture.

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An Overview towards Botanicals from Medicinal Plants in Stored Insects

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The use of synthetic chemical insecticides is not allowed or is used restrictively because of the problem of residues and the health risks of consumers. With this in mind, plants are needed that can provide potential alternatives to the currently used insecticides, as they are a rich source of bioactive molecules. Available literature indicates that the plant could be a source of new insecticides. Preventing food loss during post-harvest storage is of the utmost economic importance. Integrated pest management is now a widely accepted pest management strategy, including post-harvest pest management using chemical insecticides with disinfectants. Therefore, there is great potential for insecticidal compounds derived from plants. This article focuses on the current status of botanical insecticides as grain protectors and how they work. The control of this insect is highly dependent on the use of synthetic insecticides and disinfectants. But its widespread use has created serious problems. The increasing resistance of stored product insects to conventional synthetic pesticides, along with growing concerns over environmental and human health impacts, has spurred interest in alternative pest management strategies. Botanicals derived from medicinal plants have emerged as promising candidates due to their diverse bioactive properties and eco-friendly nature. This review provides a comprehensive overview of the current knowledge on the use of botanical extracts for controlling stored insects. It discusses the various modes of action, including repellency, toxicity, and growth inhibition, and highlights the most effective plant species and their phytochemical constituents.

Keywords: Medicinal; plants; disinfectant; insecticide; health risks; compounds; dependent.

1. INTRODUCTION

“The loss of grain due to insect attacks during storage is a serious problem, especially in developing countries. Insect losses are more than direct losses. High content of insect remains preserved cereals that are not fit for human consumption and food loss and in terms of quality and quantity. Changes caused by infection of insects during storage, the environment can cause hot, wet "hot spots" that suitable storage conditions for mushrooms that cause additional losses. It is estimated that more than 20,000 types of fields and storage pests destroy about a third of the world food production worth more than $ 100 billion a year of which the largest losses (43%) in developing” [1-2]. “Natural products from plants are shown as powerful two-rational alternatives to synthetic insecticides for integrated management of insects after the harvest. Pesticide plants, as an alternative to synthetic pesticides, are known for their non-cytotoxicity, their ease of biodegradation and their modeling of host metabolism. Pesticide compounds grow quickly, making them greener than synthetic compounds” [3-5]. “In India, there is a high availability of plants that have been characterized by their efficiency, growth, proliferation and low availability” [6,7]. “In the 1960s, their negative impact on the environment and human health became apparent. The reasons for using synthetic pesticides are their direct impact on pests, which eventually led to trade in agricultural products with pesticide residues. More than 600 species are considered pests of stored products. Among insects, the main pests are roaches, ticks, and beetles. Beetles are the largest taxon of insects and the number one order of stored product pests” [8]. “In addition, this group of insects is often resistant to insecticides and can survive in dry conditions and absorb water from poorly hydrated products. Therefore, their population is difficult to control in food storage areas. Different groups of insecticides are used against pests of coleopterans (cockroaches and ulcers), such as synthetic insecticides, fungal substances and substances of plant origin (for example, essential oils or alkaloids). Natural products make up a small percentage of the currently used insecticides” [9-11]. In some cases, we have not fully discussed some active compounds due to inconsistencies in the available data. However, if necessary, a brief overview was provided. We are also trying to discuss possible methods of using bio insecticides to protect stored crops, as well as future use of plant compounds in the future to protect stored crops. During severe infestations, skin and submerged bodies accumulate in fluffy masses which can explode. He is an ordinary resident of household dust and is very allergic [12-15]. A vacuum cleaner is required if the sites are severely infected. These signs indicate that the storage conditions are too humid. Contaminated materials should be

Table 1. List of grain pests and their life cycle

Pest Name	Common Host Grains	Life Cycle Stages	Duration of Life Cycle	Key Characteristics
Rice Weevil	Rice, Wheat, Maize	Egg, Larva, Pupa, Adult	26-32 days	Females lay eggs inside the grain kernel; larvae feed inside the grain.
Lesser Grain Borer	Wheat, Barley, Rice	Egg, Larva, Pupa, Adult	30-45 days	Highly destructive; bore holes in grains during larval and adult stages.
Red Flour Beetle	Wheat, Maize, Processed Grains	Egg, Larva, Pupa, Adult	20-25 days	Feeds on broken or damaged grains; thrives in stored grain products.
Sawtoothed Grain Beetle	Oats, Corn, Processed Grains	Egg, Larva, Pupa, Adult	30-50 days	Flattened body allows it to penetrate tight spaces in grain storage.
Granary Weevil	Wheat, Barley, Corn	Egg, Larva, Pupa, Adult	35-40 days	Adults cannot fly; larvae feed entirely within the grain kernel.
Indian Meal Moth	Maize, Rice, Processed Grains	Egg, Larva (Caterpillar), Pupa, Adult	28-35 days	Caterpillars create silk webs in stored products, contaminating food.
Angoumois Grain Moth	Wheat, Corn, Barley	Egg, Larva, Pupa, Adult	4-6 weeks	Eggs are laid on grain surface; larvae bore into kernels to feed.
Khapra Beetle	Rice, Wheat, Barley, Maize	Egg, Larva, Pupa, Adult	4-6 months	Highly resistant to starvation and desiccation; major quarantine pest.
Maize Weevil	Maize, Wheat, Barley	Egg, Larva, Pupa, Adult	30-45 days	Infests whole grains; adult weevils are capable of flight.
Confused Flour Beetle	Wheat, Corn, Barley	Egg, Larva, Pupa, Adult	26-35 days	Feeds on damaged grains and processed products; common in flour mills.

Source: Shadia 2011 [7]

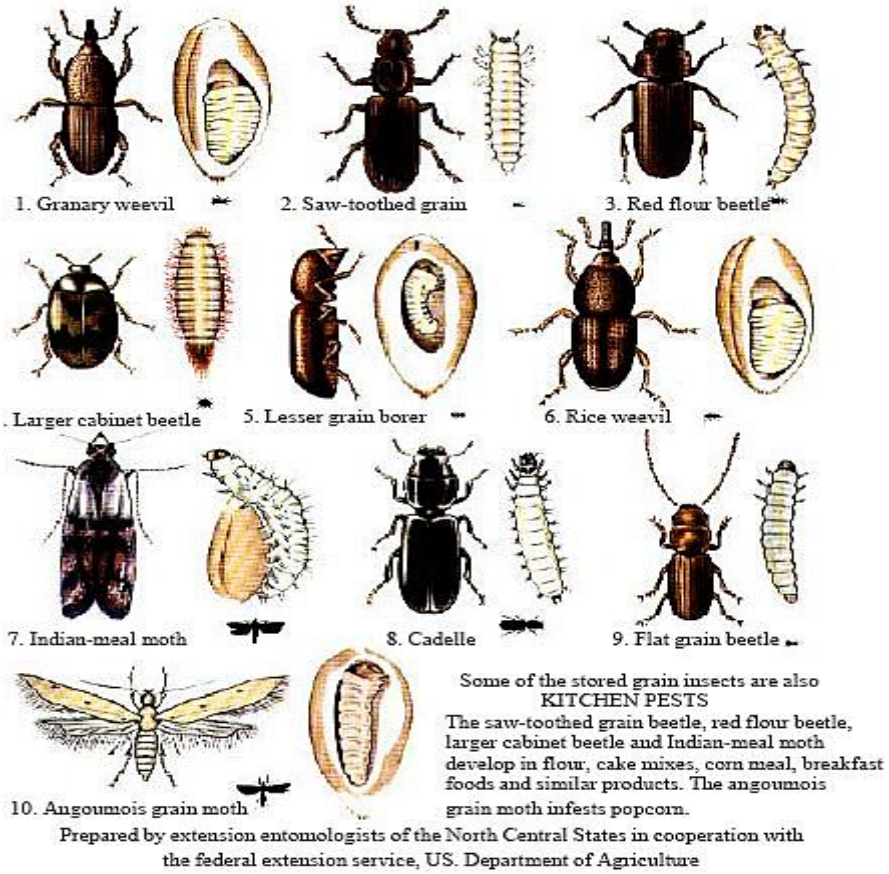


Fig. 1. Microphotographs of kitchen pests

removed and contaminated areas should be thoroughly cleaned. Botanical insecticides currently play only a minor role in insect control and plant protection; increasingly stringent legal requirements in many jurisdictions have prevented a handful of botanists from entering the market in North America and Europe for the past 20 years [16-19]. However, public health requirements and regulations create opportunities for the use of plant products in industrialized countries, in situations where human and animal health is critical, to combat pests in and around homes and gardens, commercial kitchens, and storage. food and meal. in pets [20-23].

2. USES OF BOTANICALS FOR STORED INSECTS

"The biological nature of botanical pesticides accelerates their degradation and therefore does not accumulate in the environment, for example in water and soil, thereby eliminating contamination risks" [24]. "Vegetables have been used since time immemorial to protect stored food from common pests. They act as repellents, antioxidants, toxins and act as natural defenders of grains, acting as chemo stimulants / reproduction inhibitors or inhibitors of insect growth and development" [25,26]. "The concept of using natural sources to a store of various household items has been around for centuries. When modern means were not available. Here evidence of ash, sand, herbs, and herbs used in ancient civilization that was used for expansion shelf life of many foods. Many of these practices they find their confidence even in the modern era, as these methods they are profitable and sustainable. The main activity is due to the presence of volatile lipophilic essential oils secondary metabolites. Many spices and herbs and their extracts are known to have insecticidal properties, which often present in the essential oil fraction" [27-31].

3. TRADITIONAL METHODS FOR STORED INSECTS

"Only some other plant materials show a decrease in commercial use as insecticides, as

the wood of the Caribbean tree *Ryania speciosa* (Salicaceae) contains a number of unique alkaloids that block neuromuscular compounds. Shredded stem wood containing Al% ryanodine and its alkaloid analogs was used to produce organic fruits. *Quassia amara* (Simaroubaceae), a small tree from Brazil, contains bitter triterpenoids. The wood chips and bark of the land of this species and the associated tree Ailanthus altissima have traditionally been used as an insecticide. Sabadilla is a powder based on ground seeds of *Schoenocaulon officinale* (Melanthiaceae), a plant from South America. Pure active substances, the steroid type alkaloids, are quite toxic to mammals, but, like rotenone, the concentration of alkaloids in powdered seeds is quite low, which provides a margin of safety for the user" [32-35].

a. Pyrethrum: Pyrethrum is the most widely used botanical insecticide in the world and is known as a rapidly disintegrating household spray.
b. Pyrethroids: It is synthetic materials designed to imitate natural pyrethrum but are much more toxic and long lasting.
c. Rotenone: Rotenone is an isoflavonoid obtained from the roots or rhizomes of tropical legumes in the genera Derris, *Lonchocarpus* and *Tephrosia*.
d. Nicotinoids: They have been previously referred to as nitro-guanidines, neonicotinyls, neonicotinoids, chloronicotines and more recently as the chloronicotinyls.

4. FUMIGATION

The currently used fumigants, phosphine, methyl bromide, This is consequence, there is an increasing necessitates for development of safe alternative that could replace the toxic fumigation against stored product insecticides. *Sitophilus zeamais* is and the red-flour beetle, *Tribolium castaneum* and demonstrates both repellent and fumigant properties. The exact mode of action of these oils as fumigant is unknown but the oils mainly act in the vapor phase via respiratory system. Alkaloids isolated from *Annona squamosa* have shown larvicidal growth-regulating and chemosterilant activities against *Anopheles stephensi*, *Callosobruchus chinensis*, causing nearly 100% sterility at a concentration of 1.5%. Fumigation plays a major role in insect pest elimination in stored products. Currently, phosphine (from metal phosphide preparations, cylinderized formulations and on-site generators) and methyl bromide (available in cylinders and metal cans) are the two common fumigants used for stored-product protection world over.

The following areas of research need attention for the exploitation of these natural products as alternative fumigants for stored-product insect control:

1. Stability of plant products as fumigants.
2. Screening of plant essential oils/compounds for fumigant toxicity must include egg and pupal stages, diapason larvae or mixed-age cultures of target insect species
3. Validation of mixtures containing carrier gases or adjuvants for essential oils.
4. Sorption and tainting aspects must be addressed for potent essential oils/components with different types of food commodities
5. Fumigant toxicity of essential oils/constituents to *C. cephalonica*, *A. fasciculatus*, *C. serratus*, *Cryptolestes* spp. and insect pests of animal products (except D. maculatus).
6. Fumigant action of compounds from neem seed or oil, seaweeds and other marine natural products needs to be investigated [36-39].

5. FUTURE OF BOTANICALS

Vegetables are useful in the case of documented resistance of the diamond moth to *Bacillus thuringiensis* and spinosad because of. Plants are useful in case of documented resistance to diamond moths against *Bacillus thuringiensis* and spinosad due to overuse [40]. Vegetables help prevent the discharge of thousands of tons of pesticides to Earth; they are safer for the user and for the environment because they decompose by microorganisms and decompose into harmless compounds in a matter of hours or days in the presence of sunlight.

6. INSECTICIDAL ACTIVITY

The percentage of variation in the sensitivity of stored grain insect pests is high in response to toxicity of volatile compounds, currently control of stored-product insects of cereals in store were ... In this work extended to the search of insecticidal activity are observed are, *Morinda lucida*, *Callosobruchus maculatus*, rice weevil, *Sitophilus zeamais* Motschulsky., *Sitophilus oryzae* L.,

Callosobruchus maculatus, *S. oryzae*, *R. dominica*, *P. interpunctella*, So, we recommended using botanical insecticidal and being promoted and research is being conducted to find new sources of botanical insecticides. Some recent publications are cited in the ascending order which covers the studies on Botanicals from Medicinal Plants in Stored Insects, case studies, research and review communications are as follows:

7. CONCLUSION

The fact that small holder farmers have the knowledge of using pesticide plants which they hardly use, there is a need of a research based solution on better ways to make the knowledge useful. Practical research based in field situation and that directly involve small scale farmers is important to put into practice experts' understanding. There have been many laboratory studies of plant products as fumigants against insect pests of stored foods. In addition to toxicity tests, special attention was paid to elucidating the way it acts on insects. For some natural compounds, the effect on food quality, germination and seedling growth was studied. However, the following research areas require special attention to study these natural products as alternative fumigants for controlling insects in stored foods.the utilization of botanicals derived from medicinal plants presents a promising and sustainable approach to managing stored insect pests. These natural compounds offer a safer alternative to synthetic pesticides, reducing the risk of environmental contamination and human health hazards. The diverse modes of action exhibited by botanical extracts, such as repellency, toxicity, and growth inhibition, contribute to their effectiveness in pest control. However, to fully realize the potential of botanicals, further research is needed to identify the most potent plant species, optimize extraction methods, and understand the mechanisms underlying their insecticidal properties. Additionally, the development of standardized formulations and field trials will be crucial for the successful integration of botanicals into pest management programs. By continuing to explore and harness the bioactive properties of medicinal plants, we can enhance sustainable agricultural practices and ensure food security in the face of increasing pest pressures.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors hve declared that no competing interests exist.

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REVIEW ARTICLE

An overview of the effect of integrated nutrient management on vegetable crops

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The overview on the effects of Integrated Nutrient Management (INM) on vegetable crops highlights its multifaceted benefits. INM integrates organic and chemical fertilizers, enhancing soil fertility and structure while optimizing nutrient supply to vegetable crops. INM practices are important in vegetable crop production, enhancing the quantity and quality of crops like tomato, brinjal, chilli, radish, carrots, cabbage, cauliflower, broccoli, okra, cucumber pumpkin, melons, gourd and leafy vegetables. By combining natural and inorganic fertilizers with bio-fertilizers, INM methods reduce input costs and enhance crop quality and nutrition. This sustainable approach optimizes nutrient use efficiency, enhances soil health, reduces environmental pollution and contributes to overall sustainability. It is essential for researchers, policymakers and farmers to promote and encourage INM practices for a more productive and environmentally friendly vegetable farming sector. This balanced nutrition leads to increased vegetables yields, improved crop quality and enhanced nutrient use efficiency. Additionally, INM practices promote sustainable soil management, reducing environmental impact and encouraging resilience to abiotic stresses. By minimizing reliance on synthetic inputs, INM contributes to economic viability for growers while preserving natural resources.

Key Words: *Sustainability; Soil health; Natural resources; Vegetables yield*

INTRODUCTION

Integrated Nutrient Management (INM) is pivotal for optimizing vegetable crop productivity while ensuring environmental sustainability. By combining organic and inorganic fertilizers alongside microbial inoculants, INM enhances soil fertility and structure, encouraging strong plant growth and higher yields. By limiting losses and the hazards of environmental contamination associated with synthetic fertilizers, this strategy maximizes nutrient efficiency. As so, it improves soil quality, crop water uptake efficiency and soil health. Furthermore, INM reduces the need for pharmaceutical treatments by encouraging resilience to pests and environmental challenges. Notably, the method improves crop quality, satisfying customer demands for superior, nutrient-dense fruit. In terms of economics, INM maximizes input costs and supports vegetable farming's long-term viability. It is often known that vegetables are an essential dietary supplement for preserving good health and guaranteeing nutritional security. They are significant providers of proteins, carbs, minerals and vitamins. Integrated nutrient management refers to applying both organic and inorganic fertilizers to increase crop yield. Essentially, the INM approach involves applying synthetic fertilizers in addition to agricultural wastes, organic manures, biofertilizers and other biologically related materials in an equivalent ratio [1]. Farmers that cannot afford to utilize chemical fertilization to supply nutrients for any crop can also benefit from the INM approach. In order to boost agricultural output and lessen soil erosion, it also seeks to enhance the biological, mechanical, hydrological and physical qualities of the land [2]. The use of nitrogenous fertilizers excessively or carelessly is detrimental to crop productivity and soil health. Therefore, the application of biofertilizer and organic manure in moderation in addition to chemical fertilizers promotes soil fertility maintenance and lucrative and sustainable crop production [3]. When viewed appropriately, integrated nutrition management can help improve the quantity and caliber of vegetables produced [4]. By combining different nutrient sources, the INM strategy seeks to maximize vegetable crop nutrient usage efficiency. Using both natural and artificial fertilizers in addition to other management techniques, this strategy guarantees crop production that is both ecologically benign and sustainable. INM has drawn a lot of attention lately and is now a significant part of managing vegetable crops [5].

Need of integrated nutrient management in vegetable crops production

Improved soil fertility: In addition to chemical fertilizers, the regular use of organic manures such compost, farmyard manure and green manure helps enhance the fertility, texture and structure of the soil. Better nutrient availability, aeration and water retention result from this, all of which are essential for the growth and development of vegetable crops.

Increased yield and quality: Increased crop yields and better quality characteristics, such vegetable size, color, taste and nutritional content are frequently the outcomes of proper nutrient management using integrated nutrient management. Optimal plant growth and development are supported by balanced nutrition, which raises productivity and produces goods that may be sold.

Enhanced nutrient availability: INM ensures a balanced supply of essential nutrients, including Nitrogen (N), Phosphorus (P), Potassium (K), micronutrients and organic matter. This balanced nutrition promotes vigorous vegetative growth, root development, flowering and fruit set in vegetable crops.

Enhanced soil health: Through the addition of organic matter and the development of beneficial microbial communities, INM methods increase biological activity in the soil. This promotes improved nitrogen cycling, soil health and the long-term sustainability of vegetable cropping systems. It also inhibits soil-borne diseases.

Resistance to abiotic stress: Vegetable crops are more resilient to abiotic stressors like salt, drought and high temperature changes when they are properly nourished, especially when it comes to balanced levels of macro- and micronutrients. Plants that receive proper nutrition are more resilient to environmental shocks and can continue to produce even under difficult circumstances.

Reduced nutrient losses: INM assists in lowering nutrient losses due to volatilization, runoff and leaching by using organic nutrient sources and effective nutrient management techniques. By doing this, the chance of environmental contamination is reduced, nutrient utilization is enhanced and natural resources are preserved.

Improved economic returns: In spite of the possibility of greater upfront expenses associated with organic inputs and management techniques, INM usually yields longer-term advantages. For vegetable producers, more yields,

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better quality, less input needed and more environmental sustainability all translate into higher financial benefits.

Adaptation to climate change: INM techniques can improve crop resilience, water usage efficiency and soil carbon sequestration, all of which can help vegetable production systems adapt to climate change. Sustainable nutrient management practices support agricultural resilience and lessen the negative effects of climatic variability.

LITERATURE REVIEW

Effect of integrated nutrient management in Solanaceous vegetables

Tomato: INM optimizes tomato cultivation through a blend of organic and chemical fertilizers, microbial inoculants and efficient practices. Growers and the environment all gain from this all surround strategy, which improves tomato output, quality and sustainability. In tomato variety Kashi Amrit, the integrated application of 100% Recommended Dose of Fertilizers (RDF)+*Azotobacter*+Phosphate Solubilizing Bacteria (PSB)+Vesicular Arbuscular Mycorrhizae (VAM) may give the highest fruit production together with favorable fruit set and quality characteristics [6]. According to Singh et al., tomato plants treated with 50% RDF+10 t ha^{-1} Farm Yard Manure (FYM)+5 t ha^{-1} poultry manure+biofertilizer had the highest number of leaves per plant, the most fruits per plant, the longest fruits per plant, the mean fruit weight, the yield per plant, the yield per plot and the highest ascorbic acid content [7]. According to Sepat et al., applying 50% Nitrogen Phosphorus Potassium (NPK)+FYM+*Azotobacter* resulted in values for $plant^{-1}$ height, branches, fruit clusters, fruit size, fruit weight and fruit yield $plant^{-1}$ in tomatoes [8]. By utilizing both organic and inorganic fertilizers in integrated nutrient management, the soil environment is enhanced, the nutrient level is maintained and the perfect conditions are created for the healthy development of tomatoes with large yields [9].

Brinjal: INM maximizes brinjal cultivation by blending organic and chemical fertilizers, biofertilizers and efficient practices. Customized nutrient programs are guided by soil analysis and organic inputs such as farmyard manure and compost are added to the soil to enhance it. Paswan et al., found that the fruit production metrics, such as fruit number per plant, fruit length, fruit diameter, fruit weight and fruit yield per hectare, considerably improved with soil treatments of 100% NPK+25% N through vermicompost [10]. Brinjal output is increased and soil health is maintained with the application of 50 kg nitrogen through urea and 50 kg nitrogen through chicken manure per acre [11]. Under vermicompost at 10 t/ha+75% RDF (NPK), noticeably higher values of yield characteristics were reported, including fruit yield per plot and fruit yield ton per hectare. Under control FYM at 20 t/h+75% RDF, however, noticeably minimum values of yield characteristics were noted [12].

Chilli: The effects of NPK, organic manure and their combination on the development, yield and nutrient absorption of chilli plants were studied by Altaf et al., [13]. The fruit's width, length and weight increased significantly, as did the plant's height at harvest, the number of branches per plant and the number of fruits per plant. In a similar manner, NPK 100%+FYM at 8 tons per hectare increased ascorbic acid concentration and oleoresin production. The yield was increased by using FYM at 8 tons per acre together with NPK 100%. In an experiment on integrated nitrogen management in chillies, Behera et al., sought to ascertain the effects of various combinations of nitrogen sources on chilli production, uptake, quality measures and economics [14]. Due to a 50/50 mixture of urea and vermicompost, T5-50% RDF+50% N *via* vermicompost exhibited the greatest levels of chilli production, including fruit output (14511.4 kg hectare) and nitrogen absorption by fruit (122.31 kg hectare). In terms of chilli quality attributes such oleoresin, capsaicin and ascorbic acid (100 percent RDF), T2 had the greatest B:C ratio.

Effect of integrated nutrient management in Cucurbitaceous vegetables

INM plays an important role in the cultivation of cucurbitaceous vegetables such as cucumbers, pumpkins, water melon, musk melon, bitter gourd, bottle gourd and pointed gourd etc. In an experiment conducted by Singh et al., cucumber plants fertilized with RDF+vermicompost at 5 t ha^{-1}+*Azotobacter* at 5 Kg ha^{-1}+PSB at 5 Kg ha^{-1} demonstrated the highest yield and related traits [15]. This is the best integrated nutrient management approach for protected cucumber cultivation under Punjabi conditions. In soil applications of lime +biofertilizer+vermicompost@5 t ha^{-1}+RDF (100%). Nayak et al., noted the length of the vine, vine girth, number of branches per plant, length of fruit, girth of fruit, single fruit weight, moisture content of fruit, total soluble solid, ascorbic acid and total sugar of pointed gourd [16]. According to Saravaiya et al., a mixture of 50% RDF (60:30:30 NPK kg ha^{-1}) and 10 tons of bio-compost ha^{-1} should be applied to the vine in order to achieve the greater fruit output of pointed gourds (17.93 t/ha) under the INM system [17]. The ascorbic acid, protein content, shelf life, total fruit yield and benefit:cost ratio of bitter gourd plants treated with 100% RDF of NPK+FYM at 5 t ha^{-1}+Biofertilizers at 4 kg ha^{-1} (*Azotobacter* and PSB) have all reached their maximums. According to research by Patel et al., soil treatments of 75% RDN by vermicompost+25% N through urea+*Azotobacter* at 2.5 L ha^{-1}+PSB at 2.5 L ha^{-1} in bitter gourd resulted in increased growth metrics, such as vine length at 45 Days After Sowing (DAS) and at 90 DAS with the number of branches per plant at 90 DAS [18]. Applications of 50% RDF+25% Recommended Dose of Nitrogen (RDN) from Bio-compost+*Azotobacter* 2.5 L ha^{-1}+PSB 2.5 L ha^{-1} were shown to be superior with regard to several growth and yield characteristics of ridge gourd [19]. According to Patel et al., applying 50% RDF and compost to the soil was shown to be the most effective treatment for improving tiny gourd growth and production [20].

Effect of integrated nutrient management in root vegetables

INM significantly impacts the cultivation of root vegetables, such as carrots, potatoes, radishes and beets. A study on the effects of biofertilizers on carrot growth and yield was conducted by Roshni et al., [21]. The experiment used a mix of several biofertilizers and the prescribed NPK level; the factorial Randomized Block Design (RBD) design included three replications. The combination of *Azospirillum*+PSB+*Azotobacter*+VAM generated a superior outcome in terms of growth and yield characteristics, with weight of root (121.99 g), yield per plot (5.12 kg) and yield per hac (194 qt/ha). Such biofertilizers would improve long-term soil health and assist pull in more nutrients for crop development and production when used in conjunction with traditional fertilizers. Shanu et al., conducted an experiment on carrots and the results showed that 25% RDF+50% FYM at 6 t ha^{-1}+50% vermicompost at 3 t ha^{-1}+50% rhizosphere bacteria produced the highest percentage of total soluble solids, ascorbic acid content, carotene content, cortex to core ratio, highest gross return, net return and best benefit cost ratio, while FYM at 12 t ha^{-1} produced the lowest percentage of cracked and forked roots [22]. Basnet et al., found that radish grown with 50% recommended N from chemical fertilizer and 50% N from chicken manure had the highest germination percentage, plant height, root length, root diameter and yield per hectare [23].

Effect of integrated nutrient management in bulb vegetables

Two significant bulbous vegetable crops grown in India are onions and garlic. Higher onion yields were seen when 52.5 kg of nitrogen were applied per hectare using *Azotobacter* biofertilizer. Yadav et al., shown that applications of RDF (50%)+vermicompost (50%) at 90 DAT were associated with the maximum plant height, bulb diameter, neck thickness, bulb length and number of leaves per plant [24]. In a study conducted on onion INM, Brinjh et al., discovered that the RDF 75%+vermicompost 25% produced the highest plant height, whereas the RDF 75%+*Azotobacter* 25% produced the longest leaves, most leaves, thickest necks and most scales. Whereas bulb diameter, length and yield were noted in 75% RDF+25% phosphobacteria [25]. With the application of 100% RDF+vermicompost at 6 t ha^{-1}+sulphur at 45 kg ha^{-1}, which was tested by Kumar et al., the maximum plant height, number of leaves at 120 Days After Planting (DAP), maximum yield $plot^{-1}$, yield ha^{-1}, average fresh weight, average dry weight of bulb, equatorial diameter, polar diameter, average fresh weight of cloves, number of cloves $bulb^{-1}$, length of cloves, neck thickness and dry matter content were recorded in garlic [11]. According to research by Patil et al., applying 120:60:60::N:P:K (RDF) kg/ha+20 t FYM/ha produced the greatest values of all growth parameters, including number of umbels/plant, number of seeds/umbel, weight of seeds/umbel, 1000 seed weight and maximum seed yield [26]. According to Mahanthesh et al., under irrigated circumstances throughout both the kharif and rabi seasons, the plants given *Azospirillum*+100% NPK (125:50:125 kg/ha) recorded the maximum plant height, number of leaves, neck thickness, bulb diameter, bulb weight and bulb yield [27]. Jawadagi et al., used RDF (125:50:125::N:P:K kg/ha)+FYM at 30 t/ha to onions and recorded the maximum leaf length and number of leaves [28]. According to Vachan et al., applying 100% RDF+*Azospirillum*+PSB produced the maximum bulb yield and yield components, including bulb weight, diameter and length, as well as gross and net returns [29]. The application of 60 kg Nitrogen (N)+36 kg Phosphorus pentoxide (P_2O_5)+60 kg Potassium oxide (K_2O) per hectare+vermicompost at 15 t/ha produced the highest plant height, stem

diameter, leaf length, leaf breadth and yield components in garlic [30]. Verma et al., found that while the application of 5 t/ha vermicompost and 60 kg/ha sulphur together was superior in terms of weight of bulb, bulb yield and net returns of garlic, the application of 7.5 t/ha vermicompost and 90 kg/ha sulphur individually produced maximum plant height, number of leaves per plant, chlorophyll content in leaves, fresh weight of leaves, neck thickness, number of cloves per bulb, weight of bulb, bulb diameter and bulb yield [31]. According to research by Damse et al., the application of 75:40:40:40 kg Nitrogen Phosphorus Potassium Sulfur (NPKS)+7.5 t FYM+3.75 t poultry manure per hectare produced the highest bulb yield and benefit-cost ratio, indicating that garlic benefited from the application of lower doses of chemical fertilizers combined with one or two organic sources [32].

Effect of integrated nutrient management in leafy vegetables

Spinach growth and production were shown to be enhanced by using various combinations of nutritional sources. The best method for improving spinach growth and yield was determined to be an integrated application of 50% RDF+50% RDF using VC (vermicompost) [33]. Khadse et al., conducted a research with nine treatment combinations and four replications using a factorial randomized block design [34]. In addition to three vegetables-coriander, fenugreek and spinach-three nitrogen sources are employed in the treatments: 100% nitrogen from urea, 50% nitrogen from FYM+50% nitrogen from urea and 50% nitrogen from FYM+50% nitrogen from vermicompost+biofertilizers. All crop growth parameters were considerably boosted by using 50% nitrogen *via* FYM+50% urea, then 50% nitrogen *via* FYM+50% nitrogen *via* vermicompost+biofertilizers. 50% N *via* FYM+50% N *via* urea was the highest producing INM treatment; it was followed by 50% N *via* FYM+50% N vermicompost+biofertilizers.

Effect of integrated nutrient management in other vegetables

Okra: Applying NPK (100:50:50 kg/ha)+PSB (7.5 kg/ha) will maximize okra's growth and production. In addition to maintaining soil health in okra, the application of N, P and K at 37.5:37.5:37.5 kg per hectare and vermicompost at 1 t per hectare combined with microbial consortia at 3.5 kg per hectare enhanced fruit output. Okra yield was observed to increase using a combination of N, P and K at 50:50:50 kg per hectare with FYM at 10 t per hectare [11]. Maximum plant height and maximum number of leaves were also noted when Azotobactor+PSB+NPK at 120:60:60 was applied. The highest average fruit length was discovered when PSB+NPK at 100:50:50 was used. In terms of the various growth characteristics, treatment with Azotobactor+PSB+NPK at 100:50:50 resulted in yield and quality reports that were considerably higher [35].

DISCUSSION

Integrated Nutrient Management (INM) is a sustainable approach to nutrient management in vegetable crops, offering multifaceted benefits. By combining organic and chemical fertilizers, integrated nutrient management improves soil fertility and structure, optimizing nutrient supply. This approach reduces input costs, enhances crop quality and nutrition and contributes to overall sustainability. By promoting integrated nutrient management practices, it enhances vegetable yields, improves soil health and reduces environmental impact. By minimizing reliance on synthetic inputs, INM contributes to economic viability for growers while preserving natural resources. INM techniques produce ideal growth conditions for vegetable crops by boosting microbial activity, replenishing organic matter and improving soil structure. Therefore, INM practices are significant for a more productive and environmentally friendly vegetable farming sector. Therefore, researchers, policymakers and farmers should promote INM practices for a more productive and environmentally friendly vegetable farming sector [2]. The improvement in production and quality is one of the main impacts of INM on vegetable crops. INM guarantees that crops receive the vital nutrients needed for their growth and development by offering a balanced supply of nutrients. Using both organic and inorganic fertilizers together ensures a steady supply of nutrients for the duration of the growth season. Vegetables with this consistency have better sizes, colors and tastes and their yields are increased. For instance, it has been demonstrated that INM increases fruit size, improves lycopene content and raises the total marketable output in tomato growing [6]. Not only can INM increase crop production and quality, but it also plays a major role in promoting soil health. Aeration, water-holding ability and soil structure are all enhanced by adding more organic matter to the soil through the use of biofertilizers and organic manures. These enhancements encourage the growth of advantageous soil microbes, which are essential to the cycling of nutrients and their availability to plants. Consequently, the soil's long-term fertility is preserved, which lessens the requirement for chemical inputs during subsequent growth seasons.

INM can lessen reliance on chemical fertilizers, which is one of its main benefits. Even while chemical fertilizers are useful, they can be expensive and have unfavorable long-term consequences on the ecosystem and soil health. Without sacrificing the yield of their vegetable crops, farmers can lower the total amount of chemical fertilizers applied by using organic sources of nutrients, such as compost or farmyard manure. In addition to lowering input costs, this decrease in chemical fertilizer use also lessens the environmental risks such as soil deterioration, water pollution and greenhouse gas emissions that come with over-fertilizer application. Moreover, by reducing the negative environmental effects of intensive farming, INM supports sustainable agricultural practices. It promotes the use of environmentally benign and sustainable fertilizer sources, which helps ensure the long-term viability of agricultural systems. Furthermore, INM-grown vegetable crops frequently exhibit greater resistance to biotic and abiotic stressors. Because of the balanced nutrient supply that INM offers, plants are more resilient to environmental challenges like drought and severe temperatures as well as diseases and pests. Farmers may profit greatly from INM in terms of the economy. By lowering the demand for pricey chemical fertilizers, integrating several nutrition sources can save costs. Farmers may lower their total input costs while maintaining or even increasing crop yields by using locally sourced organic manures and biofertilizers. In addition to its environmental advantages, INM's higher profitability makes it a desirable choice for vegetable producers [32].

Future aspects of integrated nutrient management

Future demand for Integrated Nutrient Management (INM) in vegetable production is expected to rise due to the growing importance of sustainability in agriculture. INM offers a holistic approach to nutrient management, improving soil health, reducing environmental impact and encouraging ecosystem resilience. With population growth and climate change challenges, INM is significant for crop resilience and adaptation. The development of INM procedures is driven by customer demands for premium, sustainably produced vegetables. Data-driven decision-making and precision agriculture can maximize fertilizer applications and increase vegetable production output.

CONCLUSION

Integrated Nutrient Management (INM) is a sustainable approach to nutrient management in vegetable crops. It involves combining organic and chemical fertilizers, enhancing soil fertility and structure and optimizing nutrient supply. This approach reduces input costs, improves crop quality and contributes to overall sustainability. By promoting INM practices, it enhances vegetable yields, improves soil health and reduces environmental impact, promoting economic viability and preserving natural resources. By combining bio-fertilizer and organic manure in moderation, INM promotes soil fertility maintenance and sustainable vegetables production. By combining natural and artificial fertilizers, INM ensures ecologically benign and sustainable crop production, making it a significant part of vegetable crop management. INM's capacity to promote soil health is one of its main advantages. INM techniques produce the ideal growth conditions for vegetable crops by boosting microbial activity, replenishing organic matter and improving soil structure.

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Nesting materials preferences of common terrestrial birds

Firdous Khan, Anchal Sharma, Gayathri PM and Manish Jangid

Abstract
Nesting materials of birds was studied out at 10 different sites in Jhalawar Region of Rajasthan. During the study total 127 nests were found of 15 different species belonging to 15 families out of them maximum number of nests were of Baya weaver birds and highest number of nests were observed at site I (College of Horticulture & Forestry). Three types of nesting sites were recognized for nests in all the study sites. Most of the species, about (n=80) built nests on trees; (n=30) in building spaces (roof, cornice, hole, crevice in wall, intersecting corner of building wall, ventilator (n=17) in electrical pillar, electrical box or air condition box. In nest construction, 28 types of materials were recorded of which twigs were the most used materials, other materials found in nests included: leaves, grass blades, fibers, feathers, dry sticks, cobwebs, straw, creepers, saliva of birds, cotton, plastic or polythene, wool, human hair, papers, grass roots, coir, rubbish, rootlets, barks, dry paddy, animal fur, rope, net, pieces of cloth, ribbons, glossy chocolate paper, moss, honeycombs.

Keywords: Nest, material, birds

Introduction
In developing countries, agricultural land use pattern constitutes an essential driver of biodiversity loss. The future threat to near threatened and globally threatened bird species was found to be the current farming technique (Green *et al*., 2019) [6]. Habitat destruction and degradation has become one of the greatest threats to the biodiversity (Hamer *et al*., 2015) [9]. Maintenance of rich biodiversity in the agro-ecosystems has become an important measure to maintain high abundances of well adapted beneficial species. It is a major step towards ecological sustainability (Duelli, 1997) [4]. Different bird species are accommodated by different agricultural habitats. Highest species diversity is found in fallow land (62) followed by wetland (53), cropland (37) and lowest in plantations (31) by Mariappan *et al*., 2013 [11].
For conservation purpose it is important to study about their nesting ecology or nesting patterns. Nests is a place purposely made by birds itself for egg laying and sheltering its young's, here birds incubate the eggs and guard them from predators and from against harsh climatic condition. So, nest plays a vital role in brood survival. Nests are usually used for breeding purposes but they may also be reused in the non-breeding season for roosting purposes (Skutch, 1960) [14]. Bird species build their nest on the roofs of houses, holes of walls, trees, railway station and wells. They also readily accept artificial nesting sites i.e. nest boxes for laying their eggs (Sengupta, 1982; Ali and Ripley, 1983) [13, 1]. Birds use different nesting materials for nest building naturally birds use small pieces of yarn, feathers, twigs, leaves, grasses, sheep's wool, horse or human hairs, mud's etc. When the parent birds leave their nests their young ones are defenseless they are not mature enough to defend themselves so birds construct the nests for their protection or not only to protect them from predators but also from cold as their muscles are not exercised so young ones are unable to immobilize so nest insulate them like inwoven nests in particular trap body heat, providing warmth for the chicks-but constructing these structures is a detailed and difficult undertaking. The female builds the nest by carefully weaving grasses, twigs, and scavenged yarn over a fairly long period of time. She cushions the inside with feathers, hair and fine grass, thereby further insulating the nest (Darekar *et al*., 2015) [3].

Materials and Methods

Study Area

Jhalawar district is located at 24.6 N 76.15 Ein South-eastern Rajasthan. Jhalawar is a part of Hadoti region and lies at the edge of Malwa plateau and has an average elevation of 312 m (1023 feet). The climate of the area is more similar to that of the Indo-Gangetic Plains, with hot summer and delightfully cold winters than to the typical arid parts of Rajasthan. In summer maximum temperature is 47 °C and in winter minimum temperature is 9.5 °C. The monsoon season spread over months of July to September is however, quite unlike and very distinct from the oppressive humid climate of the North Indian Plains. An average of 781.2 mm of rainfall keeps it cool, and gentle breezes ward off the high humidity. In Jhalawar Region 10 different study sites were selected for survey are College of Horticulture and Forestry, Jhalawar, Virendra Bhavan, Prithvi Villace Palace, Chauhan's Agriculture Farm House, Khandiya Lake, Garh Palace, Gagron Fort, Aam-Jhar Temple, Barbela Lake, Raata Devi.

Survey

Extensive field surveys were performed at 10 different selected study sites in and around Jhalawar from June 2019 - April 2020in different seasons that were rainy season, winter season and summer season. Each of the 10 selected sites was surveyed individually three times in a month. Point count and Encounter methods were used to collect the data about the nesting sites and nests. The details on ecological conditions like the host tree; parasite etc. was also studied. Birds were observed during the morning hours between 06.00 a.m. to 9.00 a.m. and between 4.00 p.m. to 06.00 p.m. with the help of 10-22x50 Nikon Binocular. Birds sighted during the study were identified using field guide (Grewal *et al*., 2016 and Grimmett *et al*., 2016) [7, 8]. Nests were observed in different areas of Jhalawar by using binoculars and photographs were taken by the DSLR Nikon camera for better identification, some of the nests were collected and placed in the wildlife lab of the Department, only those nests were collected which were fallen down from the tree of found discarded.

To survey and enumeration of the nest we followed a methodology proposed by Martin and Geupel (1993) [12], utilizing two distinct processes:

1. Searching for nests in a meticulous form throughout the entire study area
2. Observing adults carrying nest material and feeding nestlings.

During nest searching and monitoring we were cautious to minimize the impact around the nests, and minimized the attraction of predators to nests by staying as far away and monitoring nests as fast as possible. As soon as the nest was located, identification of the species nesting was conducted via observation at a distance of approximately 15 m with the aid of binoculars or via bird's call.

Result and Discussion

Total number of nests

A total of 127 nests of 15 species belonging to 15 families were observed in all the 10 selected study sites in and around Jhalawar. During the study period, out of total 127 nests, highest number of nests were observed belongs of *Ploecious phillippinus* (n=43) followed by Blue Rock Pigeon (n=14), Red vented bulbul (n=12), Indian Silver bill (n=9).The results of the study are in accordance with the study of Jahan *et al.*, (2018) [10].

Nesting materials of birds

Bird uses different materials for nest construction and different species of bird uses different material, 28 types of materials were recorded of which twigs were very common, other materials found in nests included: leaves, grass blades, fibers, feathers, dry sticks, cobwebs, straw, creepers, saliva of birds, cotton, plastic orpolythene, wool, human hair, papers, grass roots, coir, rubbish, rootlets, barks, dry paddy, animal fur, rope, net, pieces of cloth, ribbons, glossy chocolate paper, moss, honeycombs. Asian Pied Starling preferred electric poles, trees and transmission towers to build their nests at both the selected locations. Materials used for nest building was mainly twigs of trees (Ailanthus excelsa), wheat straw, fibres (Cotton, jute), grass blades, plastic bits, threads, ribbons and galvanized wires. The results of the study are in accordance with the findings of Gajera *et al.*, (2009) [5].

Spotted Munia was found to prefer trees of average height in residential areas/houses like in citrus trees or *Acacia leucophloea* trees in most of the sites. Nesting material used for building of nest was wheat straw, grass blades, tree twigs and leaves of trees. The nests of Baya Weaver bird were observed hanging from the branches of trees having two compartments. Nests of Baya Weaver Bird were found at indigenous trees (Acacia spp.) and also found on *phoenix dactilyfera* at some sites in large numbers since their behavior shows communal nesting pattern. The nesting material used were grasses (dry), leaves of trees fibers(cotton).Purple Sunbird constructed oval shaped nests suspended from twigs of plant with an opening at anterior end. Nest was made up of tree leaves grass blades and twigs of trees (*Psidium guajava, Azadirachta indica*), animal hair, news papers, cloth, plastic threads etc. The findings of the study are in accordance with the findings of Darekar *et al*., (2015) [3].

Blue Rock Pigeon, House Crow and Spotted Dove was been observed to build platform nests. These nests were mainly made up of sticks from branches of trees, tree twigs (*Acacia leucophloea, Zizyphus mauritiana, Azadirachta indica*), plastic pieces (Hangers, spoons and packaging clips), metal wires (Aluminum, iron and galvanized) and paper (wrappers, packing papers and newspaper). Nests of Blue Rock Pigeon were located on shutters of shops, sheds, ventilators, under water tanks, loft of houses and under roof spaces at different study sites. House Crow made platform nests by using twigs and mostly preferred large trees with large canopy like in this study the nest was found on trees like (*Azadirachta indica, Ficus religiosa*).The results of the study are in accordance with the study of Ali *et al.*, (2011) [2].

Red-vented Bulbul was found to construct its nests on dense shrubs including *Hibiscus rosa sinensis, Acacia leucophloea*. Nesting material used was only sticks, twigs, spider web and saliva of bird. Red-Wattled Lapwing was found to be ground nester in agricultural fields. Only one nest of common house swift was found on the anterior corner of the wall at (site –I). They are mud nesters i.e.; they build their nest using mud and saliva. The observations of the study are in accordance with the results of Jahan *et al.*, (2018) [8].

Cavities/holes were occupied by House Sparrow and Rose-ringed Parakeet and their selection of nesting material and nesting sites varies greatly at different study sites. Rose-ringed Parakeet was observed to occupy natural holes and excavated holes on indigenous trees like *Azadirachta indica* and at some other sites on exotic trees like *Eucalyptus globulus*. House Sparrow was found in crevices of roofs and electrical fittings, on street lights and space between wall and girder, windows at different study sites. The nest was found to

be consisting of grass stems, sticks of trees, feathers, plastic threads and cloth pieces. The results of the study are in accordance with the outcome of Martin & Geupel (1993) [12].

Table 1: Showing different types of nesting material used for nesting by Birds

S. No	Bird species	Nesting Materials
1	Asian Pied Starling	Twigs, sticks, wheat straw, plastic bits, threads, ribbons.
2	Red Wattled Lapwing	Pebbles, hard clay, Stones
3	Indian Jungle Crow	Sticks & twigs of plants (*Ber* and *Khair*) grasses, aluminum wires threads, iron wires, paper pieces.
4	Eurasian Collared Dove	Sticks, fibers, twigs, toffee wrappers, paper pieces
5	Spotted Dove	Sticks, fibers, twigs, toffee wrappers, paper pieces
6	Little Egret	Sticks, twigs, grasses.
7	Rock Pigeon	Sticks, twigs,
8	Tailor Bird	Grass blades
9	Red Vented Bulbul	Fibers, twigs, plastic threads, paper pieces, animal hair, spider webs.
10	Baya Weaver	Grass blades, leaves, fibers, strips of palm fronds, cloth pieces.
11	Indian Silver Bill	Sticks, twigs, grasses, piece of clothes, Human hairs, Grass blades, leaves, fibers, strips of palm frond
12	Indian Robin	Twigs, grasses and spider webs.
13	Common House Swift	Mud, Feathers.
14	House Sparrow	Grass, wires, piece of cloth, human hairs, Sticks, twigs.
15	Purple Rumped Sunbird	Dry leaves, cobwebs lichens and plant materials

Conclusion

In this study 28 types of materials were recorded of which twigs were very common, other materials found in nests included: leaves, grass blades, fibers, feathers, dry sticks, cobwebs, straw, creepers, saliva of birds, cotton, plastic or polythene, wool, human hair, papers, grass roots, coir, rubbish, rootlets, barks, dry paddy, animal fur, rope, net, pieces of cloth, ribbons, glossy chocolate paper, moss, honeycombs. Generally, due to increasing urbanization and habitat destruction and deforestations birds are forced to build their nests in human settlements which leads to the negative impacts on their biodiversity as they use some harmful materials like plastics in their nest which are affecting them badly. So, with the help of the knowledge of these nesting materials, we can provide them artificial nests which will be beneficial for increasing their breeding success.

Conflict of Interest

Not available

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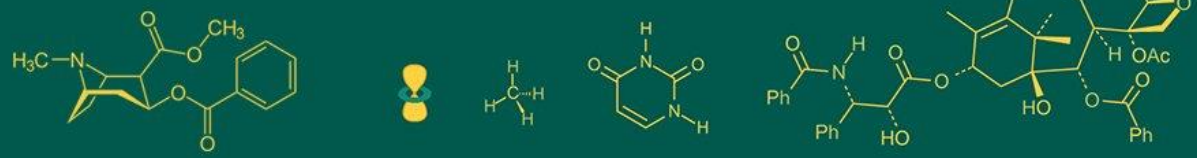
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Effects of salinity and pre-sowing treatments on the growth parameters of the *Tectona grandis* L.F. seedlings under nursery condition

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Abstract
To study the effect of different pre-sowing treatments and salinity levels on the growth parameters of *Tectona grandis* (Teak) seedling, a nursery experiment was conducted at the College of Horticulture and Forestry, Jhalawar, Rajasthan. The seedlings germinated under different pre-sowing treatments were subjected to different levels of salinity. Pre-sowing treatments consist of control (P_0), Alternate wetting and drying (12 hours) for 21 days (P_1), Soaking in cow dung slurry for 7 days (P_2) and Soaking in concentrated H_2SO_4 (75%) for 20 minutes (P_3). Salinity levels include control (0 dSm^{-1}), 3 and 6 dSm^{-1}. The experimental results showed that pre-sowing treatments had significant influence on growth attributes in seedlings. Among the four pre-sowing treatments, alternate wetting and drying for 12 hours done for 21 days (P_1) was found to be best in all growth attributes. The study also revealed that salinity levels had significant negative influences on all the growth attributes. No significant interaction between pre-sowing treatments and salinity levels on seedling growth parameters was observed during the study.

Keywords: H_2SO_4, Salinity Concentration, pre-sowing treatments, germination, teak, seedling growth attributes

1. Introduction
Tectona grandis L.F, commonly known as Teak, stands among the finest hardwoods in the world, valued for its warm hue, elegant grain, and lasting strength (Pandey and Brown, 2000) [17]. Teak grows naturally in India, Myanmar, Thailand, and the Lao People's Democratic Republic, and has also been naturalized in Java, Indonesia, possibly after being introduced 400 to 600 years ago Besides its native regions, Teak has been established in tropical areas across Asia, Africa, Latin America, and the Caribbean (Pandey and Brown, 2000) [17]. In India, key Teak forests are spread across Madhya Pradesh, Tamil Nadu, Karnataka, Kerala, Uttar Pradesh, Gujarat, Odisha, Maharashtra, and Rajasthan (Troup, 1921) [29]. Teak distribution is primarily influenced by factors such as climate, geology, and soil. (Balagopalan, 1995) [4].
Tectona grandis is globally esteemed for its exceptional qualities, making it one of the most valuable timbers in the world. Teak has probably been more extensively researched than any other tropical tree, because of its strength, durability, working qualities, and dimensional stability. Its exceptional properties make it versatile, enabling its utilization in a broad spectrum of applications, including flooring, decking, framing, cladding, electric poles, and beyond. Although Teak has a great economic value, people don't get interest in raising Teak seedling in nursery due to low germination percentage and the more average time required for the seed germination (Luna, 1996) [13]. Naturally, Teak seeds germinate within a drupe. Each drupe composed of a thin, outer exocarp surrounding a corky or thick spongy mesocarp, which in turn surrounds the woody endocarp or stone (Slator, 2013) [26]. The endocarp is four chambered containing seeds between zero to four in number, however, one seed is most common (Dabral, 1976) [7]. In most cases, only one seed of the tetralocular fruit of Teak is fully developed and other three remain undeveloped. So, Pre-sowing treatments are essential to improve the germination of Teak seeds, leading to a reduction in the overall cost of seedling establishment in afforestation/ plantation programs.

As regarding the cultivation of Teak seedlings in Rajasthan, the primary problem is salinity, attributable to the arid and semi-arid climate. (Mandal and Sharma, 2009) [14], this restricts the distribution of Teak in the entire state. Approximately 7 million ha of land is affected by salinity in India (Patel *et al*., 2011) [20]. This covers mainly in Punjab, Haryana, U.P. Bihar and some arid and semi-arid parts of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh. In Rajasthan, 0.38 million ha of land is affected by Salinity (Sharma, 2015) [23].

The presence of high salt concentrations has adverse effects on the growth of plants. (Taiz & Zeiger 2006, Ramoliya *et al*. 2006) [27, 21] and concentrations exceeding certain limits can be fatal for growing plants. (Garg & Gupta, 1997) [10]. The presence of elevated salinity causes a delay in both germination and the growth of seedlings (Bernstein 1962, Garg & Gupta 1997, Ramoliya *et al*. 2006) [10, 21].

By considering all these facts, the present investigation was performed to study the effects of different pre-sowing treatments on growth attributes and to analyze how Teak seedlings, germinated under these treatments, respond to various salt concentrations by studying their growth parameters. This will assist breeders in selecting the most effective pre-sowing treatments to enhance the growth of Teak seedlings and also to select proper selection of site for growing Teak seedlings by applying adequate management techniques to enhance the yield of Teak plantation. The information generated from the study can also be used as baseline data for the development of salt tolerant varieties of Teak through tree improvement programme.

2. Materials and Methodology

2.1 Study area

This experiment was carried out within the greenhouse facilities of the Department of Forest Biology and Tree Improvement at the College of Horticulture & Forestry in Jhalrapatan City, Jhalawar. The district is geographically located between 23º45'20" and 24º52'17" North latitudes and 75º27'35" and 76º56'46" East longitudes, with an elevation of 131.14 m above mean sea level. The climate in Jhalawar is generally sub-humid and exhibits significant temperature variations between summer and winter. During the summer, the maximum temperature can reach as high as 45.72 ºC, while in winter, it can drop to a minimum of 4.14 ºC. The region receives an average annual precipitation of about 954.7 mm, mainly from the South-West monsoon between June and September, with occasional scanty showers in the winter months.

2.2 Plant and Growth Conditions

Uniformly sized Teak seedlings of 75 days old that are germinated under different pre-sowing treatments were selected to reduce non-treatment variation. The potting media consist of soil, sand and vermicompost in 2:1:1 ratio and it was filled in polybags of size 6X10 inches.

2.3 Salinization of soil/ irrigation with saline water

The plants were irrigated daily with water of three different salinity levels of electrical conductivity (0, 3 and 6 dSm^{-1}) for 30 days. 100 ml of prepared salt solution was applied to each polybag according to layout. To prepare different concentrations of NaCl solution, NaCl and distilled water were used. Three NaCl solutions were used *viz*., control (0 dSm^{-1}), 3 and 6 dSm^{-1}. For making 3 dSm^{-1} and 6 dSm^{-1} NaCl solutions, 1.92 gm and 3.84 g NaCl was dissolved in 1000 ml of distilled water in a volumetric flask respectively. After dissolving, the electrical conductivity EC was determined using conductivity meter and expressed in ds/m.

2.4 Experimental design and layout

The present experiment was conducted to investigate the effects of salt stress on seedling growth of Teak seedlings germinated in different pre-sowing treatments. To create salt stress, NaCl was used in different concentrations. The experiment consisted of four pre-sowing treatments and three NaCl salt concentration levels were laid out in factorial completely randomized design (FCRD) with three replications. Ten polybags were maintained in each replication. The total numbers of polybags needed for this experiment were 360 (4 pre-sowing treatments×3salinity levels×3 replication per each treatment×10 seedlings per each replication).The details of the treatment used in experiment are given in Table 1.

Table 1: Treatment details

Sr. No.	Treatments	Treatment combinations	Treatment notations
1.	T_0	Control +0 dSm^{-1} salt concentration	P_0S_0
2.	T_1	Control + 3 dSm^{-1} salt concentration	P_0S_1
3.	T_2	Control + 6 dSm^{-1} salt concentration	P_0S_2
4.	T_3	Alternate wetting and drying (12 hrs) for 21 days + 0 dSm^{-1} salt concentration	P_1S_0
5.	T_4	Alternate wetting and drying (12 hrs) for 21 days + 3 dSm^{-1} salt concentration	P_1S_1
6.	T_5	Alternate wetting and drying (12 hrs) for 21 days + 6 dSm^{-1} salt concentration	P_1S_2
7.	T_6	Soaking in cow dung slurry for 7 days+ 0 dSm^{-1} salt concentration	P_2S_0
8.	T_7	Soaking in cow dung slurry for 7 days+ 3 dSm^{-1} salt concentration	P_2S_1
9.	T_8	Soaking in cow dung slurry for 7 days+ 6 dSm^{-1} salt concentration	P_2S_2
10.	T_9	Soaking in concentrated H_2SO_4 for 20 minutes (75%) + 0 dSm^{-1} salt concentration	P_3S_0
11.	T_{10}	Soaking in concentrated H_2SO_4 for 20 minutes (75%) + 3 dSm^{-1} salt concentration	P_3S_1
12.	T_{11}	Soaking in concentrated H_2SO_4 for 20 minutes (75%) + 6 dSm^{-1} salt concentration	P_3S_2

2.5 Observations recorded

At 15th day after completion of the germination period, (60 days from the day of sowing considered as the germination period) the plants were irrigated daily with water of three different salinity levels of electrical conductivity (0, 3 and 6 dSm^{-1}) for 30 days. 100 ml of prepared salt solution was applied to each polybag according to layout.

Observations for growth attributes including plant height, collar diameter and number of leaves were recorded monthly *i.e.*, at 30, 60, 90, days after salt treatment (DAST). Root length was recorded at 180 days after salt treatment.

3. Results and Discussion

3.1 Effect of pre-sowing treatments on the growth parameters

Many researchers have claimed that various pre-sowing techniques improve the germination characteristics (Teketay, 1996; Alamgir and Hossain, 2005 and Azad *et al*., 2010) [28, 1, 3]. The current study's results also showed that *Tectona grandis* seeds treated differently produced better growth outcomes.

It is evident from the data presented in the tables that various pre-sowing treatments showed significant difference on growth parameters and all the treatments showed significant difference over control for all the parameters. The seeds treated by alternate wetting and drying of 12 hours done for 21 days(T_3) recorded highest growth attributes such as shoot length, collar diameter, number of leaves and root length followed by seeds treated in cow dung slurry for 7 days (T_6). These results may be attributed to minimum number of days taken to initiate and complete germination because of faster imbibition in alternating wetting and drying (12 hours) for 21 days as compared to other treatments. Similar findings reported by Masilamani *et.al*., 1998 in Teak seeds proved soaking in water for 24 hrs followed by drying for 72 hrs, the cycle repeated for six times recorded maximum shoot length and root length whereas seedlings germinated from seeds collected from ground and without treatment recorded minimum shoot length, collar diameter, number of leaves and root length.

3.2 Effect different salinity levels on growth parameters

Salinity is one of the major abiotic stresses that affect plant growth. Plants grown in the saline medium get injured adversely because of osmotic stress, salt stress, nutritional imbalances, or by combined effect of these factors (Ashraf, 2004) [2]. The results of present investigation showed that application of salinity levels had significant influence on growth attributes; shoot length, collar diameter, number of leaves and root length.

The data regarding growth attributes showed that all the growth attributes of Teak seedling were significantly decreased with increasing the salinity in the growing medium. Among the three salinity levels, highest values of shoot length (12.91 cm), collar diameter (4.87 mm), number of leaves (4.36), root length (16.66 cm)) were recorded in control (S_0-0dSm^{-1}) whereas lowest values were recorded in (S_2 - 6dSm^{-1}). The reduction in seedling growth in salt stress may be attributed to the osmotic effect stress that caused reduction in water uptake, causing imbalance of various physiological functions (Munns *et al.*, 2020) [16]. Bernstein and Haywood (1958) also reported similar result that, reduction of growth under salt treatment is the resultant reduced water absorption. Increased salinity showed a significant reduction in leaf number may be due to reduction of photosynthetic rate with salinity (Shannon *et al*., 1994) [22]. The results are also in conformity with some earlier findings reported by Patel *et al*., (2009) [19] in *Delonix regia*. They reported that maximum growth parameters in 0.3 dSm^{-1}and minimum growth parameters in 6 dSm^{-1} .Similar results were reported by Pandey (1989) [18] in Ber. Farahat *et al*., (2013) in *Grevillea robusta*, and Kaushik (1998) [12] in *Dalbergia sissoo* also reported that seedling grown under salt stress decreased growth parameters with increasing the salinity in the growing media. Singh *et al*. (1996) [25] in *Dalbergia sissoo* reported that seedling grown under salt stress decreased growth parameters with increasing the salinity in the growing media. Similar results were also given by Shedage *et al.*, (2013) [24] in Teak. They reported that maximum shoot length, number of leaves and collar diameter were recorded in (<4 ECe) whereas minimum shoot length, number of leaves and collar diameter were recorded in (8-12 ECe).

Table 2: Effect of pre-sowing treatments and different salinity levels on shoot length (cm) of Teak (*Tectona grandis*)

	30 DAST				60 DAST				90 DAST			
Treatments	**S_0**	**S_1**	**S_2**	**Mean P**	**S_0**	**S_1**	**S_2**	**Mean P**	**S_0**	**S_1**	**S_2**	**Mean P**
P_0	7.80	6.10	5.55	6.48	9.12	6.71	5.74	7.19	9.74	7.02	5.88	7.55
P_1	10.76	9.43	8.50	9.57	12.18	9.99	8.71	10.29	12.91	10.33	8.84	10.69
P_2	9.93	8.46	7.65	8.68	11.13	8.96	7.83	9.30	11.93	9.37	7.98	9.76
P3	8.80	7.21	6.58	7.53	10.17	7.83	6.75	8.25	10.94	8.19	6.89	8.67
Mean S	9.32	7.80	7.07		10.65	8.37	7.26		11.38	8.73	7.40	
	CD (5%)		SEM±		CD (5%)		SEM±		CD (5%)		SEM±	
Factor P	0.546		0.186		0.514		0.175		0.540		0.184	
Factor S	0.472		0.161		0.445		0.152		0.467		0.159	
Factor P*S	NS		0.322		NS		0.303		NS		0.318	

DAST-Days after salt treatments, P_0 - Control: Seeds without any pre-sowing treatment, P_1- Alternate wetting and drying (12 hours) for 21 days, P_2- Soaking in cow dung slurry for 7 days, P_3 - Soaking in concentrated H_2SO_4 (75%) for 20 minutes, S_0- Control, S_1 - 3 dSm^{-1}, S_2 - 6 dSm^{-1}

Table 3: Effect of pre-sowing treatments and different salinity levels on collar diameter (mm) of Teak (*Tectona grandis*)

	Number of days after salt treatments											
	30 DAST				60 DAST				90 DAST			
Treatments	S_0	S_1	S_2	Mean P	S_0	S_1	S_2	Mean P	S_0	S_1	S_2	Mean P
P_0	2.46	2.03	1.68	2.06	3.26	2.38	1.80	2.48	3.51	2.51	1.87	2.63
P_1	3.44	3.11	2.7	3.08	4.25	3.46	2.82	3.51	4.52	3.58	2.88	3.66
P_2	2.92	2.55	2.16	2.54	3.74	2.90	2.18	2.94	4.00	3.04	2.26	3.10
P3	2.70	2.31	1.98	2.33	3.52	2.66	2.10	2.76	3.77	2.79	2.17	2.91
Mean S	2.88	2.50	2.13		3.69	2.85	2.23		3.95	2.98	2.30	
	CD (5%)		SEM±		CD (5%)		SEM±		CD (5%)		SEM±	
Factor P	0.179		0.061		0.180		0.061		0.155		0.053	
Factor S	0.155		0.053		0.156		0.053		0.134		0.046	
Factor P*S	NS		0.106		NS		0.106		NS		0.091	

DAST-Days after salt treatments, P_0 - Control: Seeds without any pre-sowing treatment, P_1- Alternate wetting and drying (12 hours) for 21 days, P_2- Soaking in cow dung slurry for 7 days, P_3 - Soaking in concentrated H_2SO_4 (75%) for 20 minutes, S_0- Control, S_1 - 3 dSm^{-1}, S_2 - 6 dSm^{-1}

Table 4: Effect of pre-sowing treatments and different salinity levels on number of leaves per seedlings of Teak (*Tectona grandis*)

	Number of days after salt treatments											
	30 DAST				60 DAST				90 DAST			
Treatments	S_0	S_1	S_2	Mean P	S_0	S_1	S_2	Mean P	S_0	S_1	S_2	Mean P
P_0	9.36	7.94	7.03	8.11	9.91	8.35	7.19	8.48	6.58	5.17	3.92	5.22
P_1	13.18	12.63	11.07	12.29	13.87	13.10	11.27	12.75	9.44	7.39	5.46	7.43
P_2	12.06	11.03	9.78	10.96	12.68	11.46	9.95	11.36	8.24	6.87	4.99	6.70
P_3	10.67	9.45	8.47	9.53	11.31	9.90	8.69	9.97	7.36	6.24	4.53	6.04
Mean S	11.32	10.26	9.09		11.94	10.70	9.28		7.91	6.42	4.73	
	CD (5%)		SEM±		CD (5%)		SEM±		CD (5%)		SEM±	
Factor P	0.517		0.176		0.534		0.182		0.534		0.182	
Factor S	0.448		0.153		0.463		0.158		0.463		0.158	
Factor P*S	NS		0.305		NS		0.315		NS		0.315	

DAST-Days after salt treatments, P_0 - Control: Seeds without any pre-sowing treatment, P_1- Alternate wetting and drying (12 hours) for 21 days, P_2- Soaking in cow dung slurry for 7 days, P_3 - Soaking in concentrated H_2SO_4 (75%) for 20 minutes, S_0- Control, S_1 - 3 dSm^{-1}, S_2 - 6 dSm^{-1}

Table 5: The Effect of pre-sowing treatments and different salinity levels on root length (cm) of Teak (*Tectona grandis*) at 180 DAST

Treatments	S_0	S_1	S_2	Mean P
P_0	14.55	12.49	9.85	12.30
P_1	18.53	15.37	13.42	15.77
P_2	17.25	14.19	12.37	14.60
P_3	16.31	13.12	11.12	13.51
Mean S	16.66	13.79	11.69	
	CD (5%)		SEM±	
Factor P	0.809		0.276	
Factor S	0.701		0.239	
Factor P*S	NS		0.477	

4. Conclusions

The pre-sowing treatments had significant influence on growth attributes. Among the four pre-sowing treatments, alternate wetting and drying for 12 hours done for 21 days (T_3) was found to be best among the other treatments with respect to plant height, collar diameter, number of leaves and root length and this pre-sowing treatments is easy and inexpensive. Therefore, it is recommended for large-scale adoption to produce superior *Tectona grandis* planting stock and aid in afforestation initiatives. The study also revealed that salinity levels had significant influences on all the growth attributes. All the parameters decreased significantly with increasing the salinity in the growing medium. However, the interaction effects of pre-sowing treatments and salinity levels on seedling growth parameters were found to be non-significant.

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Effects of pre-sowing treatments on germination parameters of *Tectona grandis* L.f. under nursery condition

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Abstract
A study was undertaken in the nursery area of College of Horticulture and Forestry, Jhalawar to assess the influence of different pre-sowing treatments on the germination of *Tectona grandis* (Teak) seeds. Seeds were subjected to 4 treatments including control (P_0), Alternate wetting and drying (12 hours) for 21 days (P_1), Soaking in cow dung slurry for 7 days (P_2) and Soaking in concentrated H_2SO_4 (75%) for 20 minutes (P_3). The results of the study indicated that pre-sowing treatments had significant influence on the germination parameters. The highest germination percentage, germination speed, faster germination and lowest mean germination were observed in seeds treated under alternate wetting and drying (12 hours) for 21 days (P_1) followed by seeds soaked in cow dung slurry for 7 days (P_2). Among the pre-sowing treatments seeds treated under alternate wetting and drying (12 hours) for 21 days can be recommended for *Tectona grandis* on a broad scale. These research findings will provide valuable insights for making informed decisions on the cost-effective cultivation of *Tectona grandis* (Teak) seedlings on a large scale, ensuring their rapid germination.

Keywords: Pretreatment, seed germination, *Tectona grandis*, H_2SO_4, mean germination time, germination index

1. Introduction
Teak (*Tectona grandis* Linn. f.), belongs to family Lamiaceae, is a large deciduous tree growing up to 30 m height and 100 cm or more dbh. Teak is naturally distributed in South East Asia. In India, most important Teak forest are found in Madhya Pradesh, Tamil Nadu, Karnataka, Kerala, Uttar Pradesh, Gujarat, Orissa, Maharashtra and Rajasthan (Troup, 1921) [22].
The distribution of Teak is largely controlled by climate, geology and soil (Balagopalan, 1995) [4]. Teak grows best in well drained, fairly moist, warm, tropical climate with base-rich soils having high organic carbon and exchangeable calcium with pH 6.5 to 7.5 (Kulkarni, 1951) [11]. Generally, Teak grows well in areas receiving annual rainfall ranges 800-2500 mm and from sea level to an altitude of about 1,200 m. It is distributed naturally over a wide range of rainfall; from very dry area in which the annual rainfall is less than 800 mm to the very moist areas mostly within the west coastal regions of India with an annual rainfall of over 3,500 mm (Palanisamy *et. al*., 2009) [18].
Teak is known as king of timber and it yields one of the world's most beautiful and stable wood with excellent wood quality. Teak furniture is highly durable and the durability is accredited to the deposition of polyphenols in its heartwood. Because of its high dimensional stability and easy workability, it is considered as the best timber for making furniture, cabinet, tool handles, agricultural implements, ship and boat building, decorative flooring, wall panelling, carom board frames, mathematical instruments and wood packing etc. (Luna, 1996) [4]. Apart from its use as timber, other parts of the tree such as; flowers, fruits, seeds, leaves and bark are also useful (Orwa *et. al.*, 2009) [17].
Although Teak has a great economic value, people don't get interest in raising Teak seedling in nursery due to low germination percentage and the more average time required for the seed germination (Luna, 1996) [14]. Naturally, Teak seeds germinate within a drupe. In fact the drupes

germinate slowly and irregularly if it is untreated (Jackson, 1994) [9]. The delayed and unpredictable germination of *Tectona grandis* seeds in the nursery poses a significant hurdle for effective nursery management and successful plantation establishment. Therefore, it is crucial to identify pre-sowing techniques for these seeds to ensure earlier and successful germination, ultimately aiding in the reduction of seedling production costs on a large scale.

In light of the current situation, the primary objective of this study is to explore the most suitable pre-sowing treatments for overcoming the seed dormancy and production of quality planting material of *Tectona grandis* through the use of various pre-sowing treatments and finally to recommend cost-effective pre-sowing treatments that maximize germination and other germination quality parameters of this valuable species. This will help people to minimize their production cost of seedlings on a broad scale.

2. Materials and Methods

2.1 Study area

The experiment was conducted in green house of Department of Forest Biology and Tree Improvement, College of Horticulture & Forestry, Jhalrapatan City, Jhalawar. Geographically the district is situated between 23º45'20" and 24º52'17" North latitudes and 75º27'35" and 76º56'46" East longitudes at 131.14 m above mean sea level. The climate of this region is ordinarily sub-humid and characterized by extremes of temperature both in summer and winter. Maximum temperature in summer is high as 45.72 ºC and minimum during winter is 4.14 ºC. The normal yearly precipitation within the region is almost 954.7 mm mainly received from South-West monsoon amidst June to September and sometimes meagre showers amidst winter season.

2.2 Materials

Teak seeds were collected from the selected candidate plus trees (selected by single tree selection method, Zobel and Talbert, 1984) of Teak from Jhalawar region. The details of the selected candidate plus trees of *Tectona grandis* Linn.f**.** from Jhalawar region is given in the Table 1 The collected seeds were mixed together and from the collected seeds, healthy, uniform sized and good shaped seeds were selected to reduce non-treatment variation. The potting media used for the filling the poly bags under the experiment was mixture of soil, sand and vermicompost in 2:1:1 ratio. Pre-treated seeds were sown in polybags of size 6×10 inches. There were 150 polybags in each replication and altogether 600 polybags were arranged in a single treatment. A total of 2400 seeds of Teak were sown for the germination study.

Table 1: Details of the candidate plus trees (CPTs) of *Tectona grandis* Linn.f. selected from the Jhalawar region

SL. No	Plus tree	GPS (N)	GPS (E)	Location	Total height (m)	DBH (cm)	Clear Bole height (m)	Crown spread (m)	Crown length (m)	Bark thickness (mm)	Straightness score	Bole/Taper score
1.	PT_1	24⁰58'78.73"	76⁰15'97.62"	Jhalawar	15.50	19.10	5.00	11.05	10.50	11.00	4.00	3.00
2.	PT_2	24⁰58'78.92"	76⁰15'96.25"	Jhalawar	13.50	15.12	4.50	8.90	9.00	11.00	4.00	3.00
3.	PT_3	24⁰58'92.17"	76⁰15'73.27"	Jhalawar	23.00	25.47	6.00	12.35	17.00	12.00	4.00	3.00
4.	PT_4	24⁰58'92.55"	76⁰15'71.73"	Jhalawar	11.50	16.24	3.00	10.42	8.50	10.00	3.00	3.00
5.	PT_5	24⁰62'80.29"	76⁰15 '92.60"	Jhalawar	19.50	15.44	3.50	10.45	16.00	11.00	3.00	3.00
6.	PT_6	24⁰59'03.36"	76⁰16' 07.97"	Jhalawar	9.50	18.63	4.50	8.85	5.00	10.00	3.00	3.00
7.	PT_7	24⁰53'52.29"	76⁰17'21.34"	Jhalawar	10.00	17.28	4.50	9.00	5.50	10.00	3.00	3.00

Experimental Design

The experiment was laid out in a Complete Randomized Design (CRD) in green house. Seeds were subjected to four (4 treatments) *viz*. Control (P_0), Alternate wetting and drying (12 hours) for 21 days (P_1), Soaking in cow dung slurry for 7 days (P_2) and Soaking in concentrated H_2SO_4 (75%) for 20 minutes (P_3). There were 150 polybags in each replication and altogether 600 polybags were arranged in a single treatment. A total of 2400 seeds of Teak were sown for the germination study. The experimental data recorded during the course of study were subjected to statistical analysis as per method of Variance, (ANOVA) as suggested by Fischer, 1963. The treatment effects were determined by 'F' test by using the software OPSTAT.

2.4 Data collection and analysis

Number of seeds germinated was recorded on daily basis till the end of germination. The germination was recorded up to 60 days from the date of sowing. Based on the germination count, the following germination parameters *viz*. Germination percentage, Number of days taken for first germination, Number of days taken for completing the germination, Mean germination time and Germination index were recorded.

2.4.1. Germination parameters

- **Germination Percentage**

At the end of the germination period, the Germination percentage was calculated as per the following equation (Kumar D, 2017) [13].

$$\text{Germination (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

- **Mean germination time (MGT)**

Mean germination time (MGT) was calculated according to the following equation (Moradi Dezfuli *et al.*, 2008) [15].

$$\text{Mean germination time} = \sum(Dn)/\sum n$$

n= n is the number of seeds, which were germinated on day D.
D= D is the number of days counted from the beginning of germination.

- **Germination index (GI)**

Germination index was calculated as described in the association of official seed analysis (AOSA, 1983) [2] by the following equation

$$\text{Germination index} = \frac{\text{Number of the germinated seeds}}{\text{Days of first count}} + .. + \frac{\text{Number of the germinated seeds}}{\text{Days of final count}}$$

3. Results

Pre-sowing treatments have significant effect on the germination parameters. The earliest initiation of germination was observed in P_1(14.00 days) followed by P_2 (19.75) whereas maximum number of days taken for first germination were recorded in treatment P_0 (32.00 days).The minimum number of days taken for completing germination (28.75 days) was recorded in the treatment P_1followed by P_2 (32.25) whereas the treatment P_0 recorded maximum number of days for completing the germination (43.00 days).The highest treatment germination percent was recorded in the treatment P_1(43.83%)which was statistically at par (39.67%) with treatment $P_2$and the minimum germination percent was observed in the treatment P_0 (20.50%). (Table 2)

Table 2: Effects of pre-treatment on Seeds germination, Number of days taken to initiate and complete germination and germination percentage of *Tectona grandis*

Treatments	Germination percent (%)	Number of days taken for first germination (days)	Number of days taken for completing germination (days)
P_0	20.50	32.00	43.00
P_1	43.83	14.00	28.75
P_2	39.67	19.75	32.25
P_3	33.16	24.25	36.25
C.D.	5.080	1.770	1.590
S.E(m)	1.631	0.568	0.510

The Mean germination time was differ significantly in different treatments. Significantly lower mean germination time was recorded in the treatment P_1 (20.00 days), followed by P_2(25.00 days) whereas significantly higher mean germination time (35.79 days) was recorded in the treatment P_0 (control) (Figure 1). Pre-sowing treatments had significant influence on germination index. Significantly higher germination index (3.43) was recorded in the treatment P_1 (alternate wetting and drying for 12 hours done for 21 days) whereas lower germination index (0.85) was recorded in the treatment P_0 (control) (Figure 2).

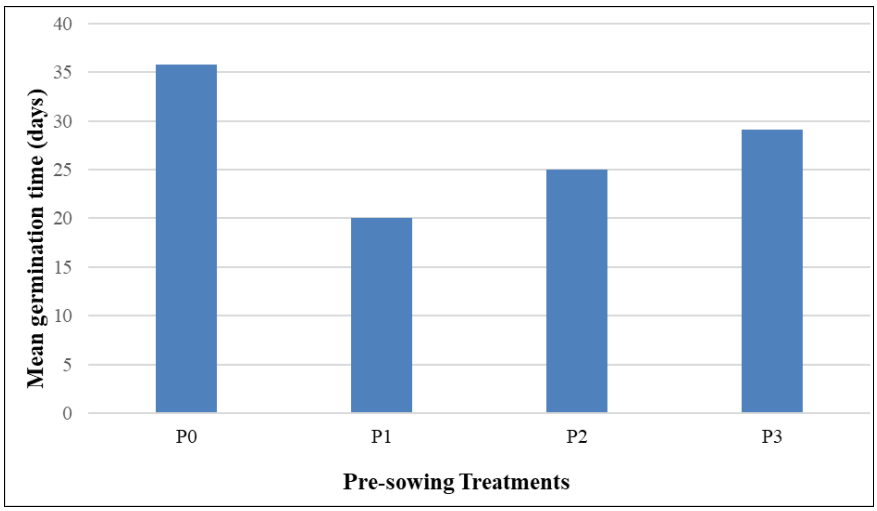


Fig 1: Effects of pre-sowing treatments on mean germination time (days) of Teak (*Tectona grandis* Linn. f.)

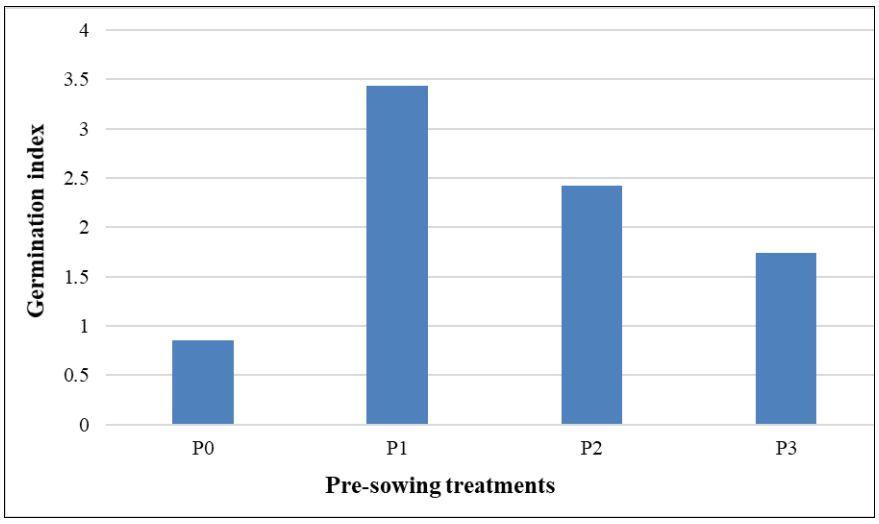


Fig 2: Effects of pre-sowing treatments on mean germination time (days) of Teak (*Tectona grandis* Linn. f.)

4. Discussion

The germination challenges of *Tectona grandis* adversely affect the quality of resulting seedlings when its seeds are sown untreated. Various authors have asserted that the implementation of different pre-sowing treatments can enhance the rate of germination and accelerate the overall germination process. (Teketay, 1996; Alamgir and Hossain, 2005 and Azad *et. al*., 2010) [21, 1, 3]. Similarly, the findings in the current study also showed that seeds of *Tectona grandis* under different pre-sowing treatments ensured better germination attributes *viz*. Germination percentage, Number of days taken for first germination and completing the germination, Mean germination time and Germination index.

The study showed that maximum germination percent (43.83%), Minimum Number of days taken for first germination (14.00) and completing the germination (28.75) was observed in P_1 followed by P_2. The maximum germination percent in alternate wetting and drying of 12 hours done for 21 days may be due to seeds soaking in water helped in softening the seed coat facilitate imbibition of water. These results are parallel to those reported by Saini *et. al*., (1999) [20] who reported that Teak (*Tectona grandis*) seeds treated with alternate soaking in fresh water for 72 hours exhibits good germination compared to control. The minimum number of days taken for first germination and complete the germination was recorded in alternate wetting and drying (12 hours) for 21 days (P_1). This may be due to expansion of cells during wetting and contraction during drying which leads to weathering of the seed coat, which could have facilitated the imbibition process. These results are in conformity with the findings of Pamei *et. al*., (2017) [19] in Teak, also noted that seeds treated by alternating wetting and drying (12 hrs) for 8 days recorded minimum number of days taken to initiate and complete the germination whereas control record maximum number of days taken to initiate and complete the germination.

Mean germination time is defined as the measure of rate and time spread of germination (Bewley *et. al*., 2013) [7]. As lower the mean germination time, faster the germination. The result of the mean germination time showed that significantly lower mean germination time (20.00 days) was recorded in alternate wetting and drying (12 hours) for 21 days (P_1) as compared to other treatments. Alternating hydration with dehydration involves a physical action that can be associated with scarification. This action results in rupture of covering layers, caused by the successive increase and decrease in seed volume (water gain and loss, respectively). Rupture of the seed coat allows water intake by the different seed covering layers (e.g., Testa and Endosperm) and seed embryo expansion (Kucera *et. al*. 2005) [10]. Uptake and loss of water result in loss of dormancy, perhaps due to reduction in germination-inhibiting hormones such as ABA in addition to the physical effect on the covering layers. By imbibing water, the seed embryo becomes biochemically active, synthesizing RNA, DNA and proteins. This leads to the emergence of the radicle which is considered as the completion of the germination process (Kucera *et al*., 2005) [10]. Likewise, similar results were elucidated by Veiga-Barbosa and Pérez-García (2014) [23] in *Plantago albicans*, N'Danikou *et. al*., (2015) [16] also noted that in *Vitex doniana* seeds treated by twenty-one days hydration – dehydration recorded minimum mean germination compared to control seeds recorded maximum mean germination time.

Germination index emphasizes on both germination percentage and its speed. Higher germination index value denotes higher germination percentage and rate of germination. (Bench Arnold *et. al*., 1991) [6]. The result of the germination index revealed that significantly higher germination index value (3.43) was found in alternate wetting and drying (12 hours) for 21 days (P_1). The study's results are in line with the observations made by Kumar (2016) [12] in Teak. Basra *et. al*., (2005) [5] in *Oryza sativa*.

5. Conclusion

The results of the present study unveiled that pre-sowing seed treatment plays a substantial role in advancing the germination process. Because of the hardness of Teak's seed coat, the germination process is prolonged, leading to a lower percentage of successful germination in nursery establishment. Despite this, the successful germination of the seeds can be ensured through the application of effective pre-sowing treatments. Out of the treatments administered in the experiment, seeds treated in alternate wetting and drying (12 hours) for 21 days (P_1) was found more effective in respect to faster germination, germination percentage and germination index. Seed germination under alternating wetting and drying is quite simple and cost-effective as it requires no particular equipment. Therefore, it can also be recommended for cultivation of *Tectona grandis* on a broad scale. The use of concentrated H_2SO_4 treatment is not advisable due to its high cost and the complications associated with its application at the local farmer level on a large scale. The study's findings will prove beneficial for nursery practitioners, offering insights into the influence of pre-sowing treatments on germination. This understanding allows them to implement these treatments effectively, resulting in the production of high-quality seedlings within a shorter time span.

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REVIEW ARTICLE

Innovative genetic approaches to minimize anti-nutritional compounds in staple crops for future food security

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Soni RK, Modi G. Innovative genetic approaches to minimize anti-nutritional compounds in staple crops for future food security. AGBIR.2024;40(4):1198-1205.

The increasing emphasis on consuming healthy food to boost the immune system is vital in addressing emerging pandemic concerns. Research in this domain encourages the diversification of human diets by incorporating highly nutritious, climate-resilient, yet underutilized crops. However, the bioavailability of nutrients and their absorption are critical in tackling malnutrition, especially in developing countries. Anti-nutritional factors such as phytic acid, gossypol, lectins and oxalic acid hinder nutrient digestion and absorption, presenting a significant barrier to effective nutrition. Traditional methods like soaking, roasting and fermentation reduce these factors but are limited to small-scale applications. Despite progress, there are substantial challenges in understanding and mitigating the accumulation of anti-nutrients in crops. Environmental factors like soil composition and fertilizer use significantly influence the expression of these compounds. Therefore, a balanced approach that incorporates advanced multi-omics and rapid estimation techniques is essential to optimize nutrient availability and develop non-toxic foods. Research indicates that while legumes are particularly high in anti-nutritional traits, crops like soybeans, *Brassicas* and cotton have seen significant advancements in reducing these factors. The integration of traditional processing methods with modern technologies, such as extrusion, offers scalable solutions to enhance food safety and nutritional quality. These combined approaches are significant in reducing hidden hunger and improving global nutritional outcomes. Future research should focus on crop-specific strategies and the stable expression of reduced anti-nutrient traits under diverse environmental conditions. This review highlights the need for continued innovation and education to promote the adoption of improved food processing methods, thereby ensuring better health and nutrition for populations worldwide.

Key Words: *Anti-nutritional factors; Nutrient bioavailability; Food processing techniques; Sustainable diets*

INTRODUCTION

The adoption of sustainable diets has substantial potential to alleviate hidden hunger in numerous countries by increasing the accessibility and absorption of essential nutrients. However, a significant obstacle to this goal is the presence of anti-nutrients in food. Anti-nutrients are substances that disrupt the digestion and absorption of nutrients, thereby decreasing their bioavailability [1]. Despite their significant impact on nutrition, these compounds have been largely neglected in research focused on addressing nutritional deficiencies and toxicities, especially with the rising global population. Anti-nutritional factors can impede digestion and nutrient absorption and in extreme cases, they can lead to serious health problems and even mortality. Consequently, it is vital to address the presence of anti-nutrients in key food crops to ensure effective mineral absorption from plant-based foods. Key anti-nutritional factors in foods include phytic acid, raffinose, saponins, tannins, enzyme inhibitors, lectins, gossypol, glucosinolates, goitrogens, oxalic acid, erucic acid, alkaloids, β-N-Oxalyl Amino Alanine (BOAA) and Hydrogen Cyanide (HCN). These substances have a significant impact on human health by hindering nutrient absorption through mechanisms like chelation and enzyme inhibition. Legumes are particularly problematic as they contain a higher proportion of anti-nutritional traits compared to other crops. This often leads to reduced consumer preference for legumes despite their potential nutritional advantages [2]. Traditional processing methods such as soaking, roasting, sprouting, fermentation, boiling and extrusion can effectively lower the levels of anti-nutritional components in grains. However, these techniques are generally used on a small scale, mainly in household cooking and some value-added agro-industrial products.

To address the limitations of traditional methods and improve nutrient bioavailability, advanced techniques like Ribonucleic Acid interference (RNAi) and gene editing are being explored. These modern agricultural technologies show potential in developing high-nutrition crops with reduced anti-nutritional factors [3]. The reduction of anti-nutritional traits has been an increasingly intense research area since the 1950s. However, there are considerable barriers to improving crop varieties by reducing these factors. The complete exploration of anti-nutrient accumulation in crops remains an ongoing challenge. While some anti-nutrients like phytic acid, raffinose, glucosinolates, enzyme inhibitors and erucic acid have been the main focus of breeding and transgenic approaches, others such as saponins, oxalic acid, alkaloids, HCN, goitrogens and BOAA need further investigation. Another critical factor in reducing anti-nutrients in crops is ensuring their stable expression across different environmental conditions. Anti-nutrients like phytic acid, glucosinolates and alkaloids are significantly influenced by soil composition, fertilizer use and other environmental factors. Therefore, alternative strategies involving advanced multi-omics, rapid estimation techniques and gene editing protocols are essential to optimize nutrient availability and develop non-toxic foods for human consumption. Additionally, it is significant to monitor the effects of reducing anti-nutrients on plant growth and metabolism. Anti-nutrients like saponins, raffinose, enzyme inhibitors, gossypol, glucosinolates and phytic acid play vital roles in regulating crop metabolism and growth. Studies indicate that these compounds influence essential aspects of crop metabolism and growth, necessitating a balanced approach to minimize negative pleiotropic effects on seed quality, yield and stability [4].

Among the primary crops, soybeans have been the most extensively researched for reducing anti-nutrient content, followed by *Brassicas* and cotton, which have also been examined to improve their acceptance for human and animal consumption [5]. This review highlights the progress made in breeding crops to reduce anti-nutritional traits and outlines future research directions in this critical area. By leveraging advanced biotechnological tools and understanding the environmental influences on anti-nutrient expression, we can develop high-value food crops with enhanced mineral availability, thereby contributing to global efforts to reduce hidden hunger and improve nutritional outcomes.

LITERATURE REVIEW

Major anti-nutritional traits in food crops and their effects on consumption

Cereal and legume-based foods contain various anti-nutritional factors that can impact their nutritional value and digestibility. Some of the key anti-

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nutritional traits that hinder food digestion and nutrient absorption include phytic acid, gossypol, lectins, raffinose, enzyme inhibitors, goitrogens, saponins, tannins, oxalic acid, erucic acid, alkaloids, BOAA and HCN. This section details the impact of consuming these anti-nutrients and provides information on their typical levels in regular diets (Table 1).

TABLE 1
The major role of anti-nutrients in consumption and plant growth regulation

S.no.	Anti-nutrient	Effects on consumption	Role in plant growth
1	Raffinose	Raffinose not digested by humans and monogastric animals	Acts as a cryoprotectant
		Leads to flatulence in humans and animals	Acts as a storage metabolite and is absorbed in seeds and roots
		Prevents non-alcoholic fatty liver disease in humans	Acts as a source of energy for seed germination
		Reduces inflammation, diabetes, allergies and obesity	-
2	Saponins	Cause diarrhea and vomiting by damaging red blood cells	Act as phytoalexin during fruit and tuber development
		Affects the nutrient absorption by gut membranes	Resistance against diseases in vegetables
		Negative impact on chick development and feed efficiency	-
3	Erucic acid	Fat accumulation in heart muscles	–
		Cardiovascular diseases and myocardial lesions in the heart	-
4	Oxalic acid	Causes headache, coma and kidney stones	Precursors of oxalic acid play a major role in climate resilience
		Calcium oxalate has a severe impact on human nutrition and health	Growth regulation of crops during pollination
		Leads to death due to oxalate poisoning	-
5	Phytic acid	Nutritional inhibitor in monogastric animals	Phosphorus storage and chelation of micronutrients for growth and development
		Decreases the risk of colon cancer and inflammatory bowel disease	-
		Lowers blood glucose level	-
6	Gossypol	Acute poisoning on ingestion	Resistance to cotton bollworm
		Causes iron deficiency known as erythropoiesis	-
		Increases cytosolic Ca^{2+} activity	-
		Decreases antioxidant levels in tissues	-
7	Lectin	Agglutinates red blood cells	Regulation of cell signaling and plant response to biotic, abiotic and symbiotic stimuli
		Anti-tumor agent	-
		Antimicrobial, antifungal, antibacterial, antiviral	-
		Alters the integrity of intestinal mucosa	-
8	Goitrogen	Deficiency of thyroid hormone	-
		Reduces growth and reproductive performance	-
		Apoptotic and anti-proliferative effects in thyroid cancer cells	-

9	Enzyme inhibitors	Trypsin inhibitors trigger pancreatic hyperplasia	Confer biotic stress tolerance and act as biopesticides
		Prevention of type 2 diabetes and obesity	-
		Protease inhibitors reduce the activity of proteolytic enzymes during ingestion	-
		Alpha-amylase inhibitors affect post-meal plasma glucose levels	-
10	Glucosinolates	Cause rancidity	–
		Prevent cardiovascular and neurodegenerative diseases	-
11	Tannins	Inhibit digestive enzymes and cause intestinal damage	Antiparasitic properties of plant tannins
		Have been associated with reduced feed intake, growth rate, feed efficiency, and protein digestibility	Act against pathogenic bacteria, have antibacterial actions and are antioxidants
		Enhance the food product's oxidative stability	Prevent neurodegenerative diseases and have anti-tumor, anti-inflammatory and antibacterial properties
		Improve the quality of the meat and milk. Act as a natural preservative	-
12	Hydrogen cyanide	In animals stops cellular respiration process due to asphyxia	–
		Severe shortness of breath and frequent urination in animals	-
13	β-N-oxalyl amino alanine	Causes neurolathyrism, a neurologic condition that is irreversible in both humans and animals	Act as an Antioxidant

Raffinose: Pulses are rich in carbohydrates, proteins, dietary fiber, vitamins, minerals and other bioactive compounds beneficial to human health. However, their global consumption, particularly in industrialized countries, is limited by the high levels of Raffinose Family Oligosaccharides (RFOs) they contain. These oligosaccharides are present in beans, cabbage, brussels sprouts, broccoli, asparagus and whole grains. RFOs ($C_{18}H_{32}O_{16}$) are especially abundant in the seeds of legumes such as chickpeas (*Cicer arietinum*), lentils (*Lens culinaris*) and soybeans (*Glycine max*). They are also found in the leaves and tubers of vegetables and other storage organs like roots. Raffinose is present in Chinese artichoke tubers (*Stachys sieboldii*) and common bugle leaves (*Ajuga reptans*). Defatted soy flour contains raffinose levels ranging from 1.15% to 3.23%, lentils contain 4.5 to 5.5 mol per 100 g of flour and faba beans contain 0.12% to 0.29%. Humans and monogastric animals cannot digest RFOs, which are instead fermented by gut microflora, producing gases that cause flatulence and discomfort [6]. Despite this, RFOs offer health benefits, including antiallergic, anti-obesity, anti-diabetic effects and prevention of non-alcoholic fatty liver disease. They improve gut microbiota health and the overall health of the large intestine, making them potential therapeutic agents for reducing inflammation, diabetes and allergies. Thus, balancing the RFO content in crops is essential for promoting them as functional foods [7].

Saponins: Saponins ($C_{58}H_{94}O_{27}$) are surface-active secondary metabolites that do not evaporate and are present in soybeans, sugar beets, peanuts, spinach, asparagus, broccoli, potatoes, apples, eggplants, alfalfa and ginseng root. These glycosidic triterpenoids are commonly found in the seed coats of various crops. Known for their structural diversity, saponins fall under triterpenes and steroid glycosides categories [8]. Their complex structures give them unique physical, chemical and biological properties, such as sweetness, bitterness and foaming and emulsifying abilities. Saponins exhibit pharmacological, medicinal, hemolytic, antimicrobial, insecticidal and molluscicidal properties. However, consuming saponins can cause diarrhea, vomiting and red blood cell breakdown. They can bind to intestinal cells, affecting nutrient absorption. In poultry, saponins negatively impact chick growth, feed efficiency and the absorption of lipids, cholesterol, bile acids and vitamins A and E.

Erucic acid: During digestion, triglycerides containing erucic acid release it into the bloodstream, where it's distributed to tissues for energy. However, cardiac muscle oxidizes erucic acid poorly, leading to fat accumulation in the heart, which can result in cardiovascular diseases and myocardial lesions.

Alkaloids: Alkaloids, particularly quinolizidine, are prevalent in commercially grown legumes. Recent advancements in detection techniques now facilitate the rapid identification of low HCN levels, significant for breeding sorghum varieties with reduced toxicity. BOAA is a neurotoxin found in both seeds and leaves. It arises as a by-product of nitrogen metabolism in plants, presenting a significant challenge in crops like *Lathyrus sativus* due to its association with lathyrism, a neurologic disorder that can lead to irreversible damage upon consumption. While extensive variation in germplasm has been observed, further research is essential to elucidate the genetic mechanisms responsible for BOAA biosynthesis. Molecular breeding techniques, including omic approaches, intron-based markers and gene editing, are currently under development to mitigate BOAA levels in *Lathyrus*, especially significant as it is a staple crop in rice-fallow systems across South Asian nations [9].

Several varieties such as Pusa-24, Pusa-305, Lysine-Specific Demethylase 1 (*LSD1*), *LSD-2* and *LSD-3* have been developed as low-BOAA cultivars, containing less than 0.2% BOAA [10]. These cultivars represent a potential avenue in agricultural research aimed at reducing the health risks associated with BOAA consumption. Efforts to standardize breeding methods emphasize the importance of genetic studies to enhance crop safety and sustainability in regions reliant on *Lathyrus* cultivation.

Oxalic acid: Oxalic acid ($C_2H_2O_4$) is a type of dicarboxylic acid found naturally as potassium and calcium salts within the cell sap of oxalis and rumex plant species. Once ingested, insoluble calcium oxalate compounds formed from oxalic acid cannot be effectively eliminated through the urinary tract. This inability to excrete calcium oxalate can lead to the development of kidney stones, posing a significant risk to human health and nutrition. Foods known to be high in oxalates include cruciferous vegetables such as kale, radishes, cauliflower and broccoli, as well as chard, spinach, parsley, beets, black pepper, chocolate, nuts, berries and beans [11]. To mitigate the potential negative effects of oxalates, it is advised to consume calcium supplements alongside foods rich in oxalic acid. This practice helps bind with oxalates in the gut, facilitating their removal from the body and thereby

reducing oxalate levels in the bloodstream. Despite its rarity, excessive consumption of oxalates can lead to serious kidney conditions and in extreme cases, fatal oxalate poisoning. Efforts to manage oxalate intake are significant, especially for individuals prone to kidney stone formation or with pre-existing kidney conditions. Monitoring dietary oxalate levels and adopting strategies to enhance calcium binding and excretion of oxalates can significantly mitigate the health risks associated with high oxalate consumption. Understanding the sources and effects of oxalates in various foods remains vital for promoting optimal kidney health and overall well-being in populations exposed to oxalic acid-rich diets.

Phytic acid: Phytic acid ($C_6H_{18}O_{24}P_6$) is an antioxidant that naturally binds with minerals like phosphorus, iron and zinc. It is predominantly found in the grains, nuts and seeds of cereals, legumes and vegetables. Notably, it is present in the rice aleurone layer and abundant in the endosperm and embryo of maize. Seeds store phosphorus mainly as phytic acid after pollination and during germination, the enzyme phytase breaks it down to aid plant growth. Monogastric animals, lacking phytase in their digestive systems, experience nutritional inhibition from phytic acid as it binds essential micronutrients [12]. The insoluble mineral-bound form of phytic acid is problematic because its excretion in animal waste can lead to eutrophication and soil pollution. Therefore, decreasing phytic acid content in grains can enhance mineral availability in foods [4]. Despite its anti-nutritional effects, dietary phytic acid has health benefits, including reducing the risk of colon cancer and other inflammatory bowel diseases due to its antioxidant properties. It helps prevent lipid peroxidation, oxidative spoilage, discoloration, putrefaction and syneresis in foods. Consequently, while reducing phytic acid in foods is significant for improving nutrient absorption and supporting normal growth and metabolism, it should be balanced to retain its beneficial properties. The recommended safe consumption range for phytic acid is approximately 250-800 mg.

Gossypol: Gossypol ($C_{30}H_{30}O_8$) is a group of polyphenols known for its potential to cause acute poisoning when ingested [13]. Research indicates that cumulative toxic effects from gossypol can manifest after just 1-3 months of consumption. To avoid toxicity, it is recommended to limit gossypol intake to 20 mg per kg of feed. Cases of gossypol poisoning have been documented in broiler chicks, pigs, dogs, sheep and goats, with monogastric animals such as pigs, birds, fish and rodents being particularly susceptible compared to ruminants. Younger ruminants are more affected by gossypol than adults. A primary consequence of gossypol ingestion is anemia, commonly observed in animals fed with cottonseed. During digestion, gossypol binds to iron in hemoglobin, forming a gossypol-iron complex that inhibits iron absorption, leading to a condition known as erythropoiesis, characterized by the fragility and death of erythrocytes [14]. This process also increases cytosolic Ca^{2+} activity, causing cell membrane disruption and contraction. Moreover, gossypol poisoning is associated with decreased antioxidant levels in tissues. At high concentrations, gossypol interferes with energy production by disrupting enzymatic activity in the mitochondrial electron transport chain and oxidative phosphorylation. Additionally, gossypol affects both male and female gametogenesis and causes embryo lesions, contributing to male infertility. Due to these properties, gossypol is being considered for potential use as a male contraceptive in future pharmaceutical research [15].

Lectins: Lectins which are complex carbohydrate-binding proteins, are glycoproteins with non-catalytic carbohydrate-binding sites and are classified into various types, including animal, algal, bacterial, fungal and plant lectins. Also referred to as hemagglutinins, these "anti-nutrients" have collected significant attention due to their involvement in obesity, chronic inflammation and autoimmune diseases. They are primarily found in raw legumes such as kidney beans, lentils, peas, soybeans and peanuts, as well as in whole grains like wheat. In leguminous plants, lectin content is highest in seeds compared to bark, leaves, roots or stems and they are commonly present in nuts, cereals and leguminous seeds [16]. Consuming lectins in their active state can cause severe adverse reactions in humans; for example, even small amounts of raw or undercooked kidney beans, which contain phytohemagglutinin, can lead to red blood cell aggregation, causing symptoms such as nausea, vomiting, stomach upset and diarrhea. Milder side effects include bloating and flatulence. Studies on animal cells have shown that active lectins can interfere with mineral absorption, affecting the levels of calcium, iron, phosphorus and zinc in the digestive tract. A safe level for lectin consumption from leguminous foods is considered to be 200-400 hemagglutinin units (hau). Despite their negative effects, lectins have demonstrated potential benefits in cancer treatment due to their antiangiogenic, antimetastatic and antiproliferative properties [17].

Goitrogens: Goitrogens (C_5H_7NOS) derive their name from "goiter" indicating an abnormal growth condition. Goiter refers to the thyroid gland's enlargement caused by thyroid hormone deficiency. Rich in goitrogens, soybean and cassava are cruciferous vegetables belonging to the genus *Brassica*, though high levels of goitrogens are also found in other cruciferous vegetables. Goitrogens disrupt iodine utilization and thyroid hormone production, leading to impaired growth and reproductive performance due to hormone deficiency. Iodine supplementation is more effective than heat treatment in mitigating the effects of goitrogens. Despite their negative impact, foods containing goitrogens also have bioactive compounds that offer protection against thyroid cancer. For instance, sulforaphane, an isothiocyanate found in crucifers, has shown apoptotic and antiproliferative effects on thyroid cancer cells. Additionally, goitrogens have been utilized in COVID-19 treatment to activate the Nuclear Factor Erythroid 2-Related Factor 2-Kelch-like ECH-associated protein 1 (*NRF2-KEAP1*) pathway and mitigate the cytokine storm induced by the virus [18]. Therefore, ensuring the safe consumption of goitrogens is essential to avoid their adverse side effects while benefiting from their positive properties.

Enzyme inhibitors: Protease inhibitors, naturally occurring in plants, are a significant area of research due to their ability to limit enzyme activity through protein-protein interactions by blocking the enzymes active sites. Compared to legumes, cereals contain much lower amounts of these digestive inhibitors [19]. Protease inhibitors can significantly diminish the activity of proteolytic enzymes during digestion. Among the various enzyme inhibitors, trypsin inhibitors and alpha-amylase inhibitors are prominent in foods. Alpha-amylase inhibitors primarily affect the breakdown of polysaccharides into oligosaccharides. By inhibiting alpha-amylase activity, these enzyme inhibitors slow carbohydrate digestion, thereby affecting post-meal plasma glucose level. Additionally, trypsin inhibitors enhance the production of hormones like steatogenic hormone and Cholecystokinin (CCK), leading to reduced food intake and body weight. In humans, the intake of trypsin inhibitors can lead to reduced growth rates, slower protein digestion, decreased amino acid availability and pancreatic hyperplasia. Research has shown that inhibiting certain enzymes, such as alpha-amylase, alpha-glucosidase and lipase, can be beneficial, enhancing the digestibility of legume-based foods. While there are health benefits, such as the prevention of type 2 diabetes and obesity, potential digestive malfunctions should be considered in future studies [20].

Tannins: Tannins ($C_{76}H_{52}O_{46}$) are plant-derived polyphenolic compounds that interact with proteins and other organic substances such as amino acids and alkaloids, forming complexes with vitamin B12 during digestion. Tannins are categorized into two types: hydrolyzable tannins and Proanthocyanidins (PAs), also known as condensed tannins. Hydrolyzable tannins are more resistant to both enzymatic and non-enzymatic hydrolysis compared to PAs, which are generally more soluble in water. Condensed tannins are particularly prevalent in leguminous forages and seeds. Tannins form complexes with dietary proteins, creating indigestible compounds that inhibit endogenous proteins, including digestive enzymes. Furthermore, tannins exhibit anti-nutritional properties, potentially causing intestinal damage, hindering iron absorption and posing carcinogenic risks. Beyond their nutritional impacts, tannic acid, a form of tannin, is utilized in the production of rubber, inks and dye fixatives. Reducing tannin content in foods can promote a healthier digestive system by minimizing these adverse effects.

Improving food safety and nutrition: Traditional and innovative approaches to combat anti-nutrients

Various traditional processing methods are utilized to improve the bioavailability of micronutrients in plant-based diets. Currently, a range of techniques is employed to mitigate the effects of food anti-nutrients, including milling, soaking, germination, autoclaving, microwave treatment and fermentation [21]. This section highlights the processing methods used to diminish anti-nutritional properties in crops (Table 2). It also details the specific processing techniques effective in reducing individual anti-nutritional factors. Recently, the market has seen the introduction of value-added products created using these methods. Traditional methods, such as milling, can physically remove parts of the grain where anti-nutrients are concentrated. Soaking can leach out soluble anti-nutrients, while germination activates enzymes that break down these compounds.

Autoclaving and microwave treatments can denature anti-nutrients through heat, making them less active. Fermentation, through microbial action, can degrade anti-nutrients and enhance the nutritional profile of foods. These processing techniques not only reduce the anti-nutritional content but also improve the overall digestibility and nutritional quality of plant-based foods.

Boiling: Boiling is an effective method to mitigate the presence of anti-nutrients like lectins, tannins and protease inhibitors in various foods. Research indicates that subjecting pigeon peas to boiling for an extended period, specifically 80 minutes, led to substantial reductions in these anti-nutrients: protease inhibitors decreased by 70%, lectins by 79% and tannins by 69%. Furthermore, studies highlight the effectiveness of boiling in reducing calcium oxalate in cooked green leafy vegetables by 19% to 87%, surpassing the efficiency of baking and steaming methods. Another investigation by Maphosa et al., observed significant improvements in the nutritional quality of beans following boiling, primarily due to decreased concentrations of lectins and saponins [22]. Boiling has been recognized for its ability to alter the chemical composition of foods, particularly by degrading or leaching out anti-nutritional compounds. The prolonged exposure to high temperatures during boiling breaks down complex structures such as lectins, which are known for their adverse effects on nutrient absorption and digestive health. Similarly, tannins, which bind to proteins and other nutrients are significantly reduced through this process, enhancing the bioavailability of essential minerals in foods. Protease inhibitors, another class of anti-nutrients that interfere with protein digestion, also undergo substantial degradation during boiling, thereby facilitating better protein utilization by the body. Comparative studies emphasize that boiling is particularly effective compared to other cooking methods like baking or steaming when it comes to reducing anti-nutrients. This method not only enhances food safety by neutralizing harmful substances but also contributes to improving the overall nutritional profile of boiled foods. By employing traditional cooking practices like boiling, food processors and consumers alike can mitigate the detrimental effects of anti-nutrients, ensuring that cooked foods retain higher levels of essential nutrients and are safer for consumption.

Autoclaving and roasting: Autoclaving and roasting are two effective cooking methods known for their ability to enhance the nutritional quality of foods by reducing anti-nutrients. Autoclaving, a process that involves high-pressure steam cooking, has been widely recognized for its efficacy in decreasing the levels of various anti-nutrients present in foods. The duration of cooking plays a significant role in determining the extent of reduction in anti-nutrient content, with longer cooking times generally resulting in greater reductions. Previous studies have highlighted that autoclaving can significantly enhance the nutritional value of foods by eliminating anti-nutrients, particularly tannins and trypsin inhibitors [23]. Roasting another heat-based cooking method, has also been investigated for its impact on reducing anti-nutrients. The study focusing on soybean meal demonstrated a significant reduction in trypsin inhibitor activity following roasting, underscoring the effectiveness of this method in improving protein digestibility. Similarly, studies involving beans have shown that heating, soaking and autoclaving can substantially decrease the levels of enzyme inhibitors and tannins, thereby enhancing the overall nutritional profile of grains. Both autoclaving and roasting work by applying high temperatures to food substances, which helps break down complex chemical structures responsible for anti-nutrient activities. Tannins known for their ability to bind proteins and inhibit nutrient absorption are particularly susceptible to degradation under these conditions. Likewise, trypsin inhibitors, which interfere with protein digestion are effectively neutralized through heat treatment, ensuring better utilization of dietary proteins by the body. These cooking techniques not only improve the safety and palatability of foods but also contribute to enhancing their nutritional value. By reducing anti-nutrient content, autoclaving and roasting play a critical role in promoting the bioavailability of essential nutrients in foods, making them more beneficial for overall health and well-being. Incorporating these traditional cooking methods into food preparation practices can help optimize the nutritional benefits derived from various food sources.

TABLE 2
The major role of anti-nutrients in consumption and plant growth regulation

S. no	Anti-nutrient traits	Traditional methods	Effective method
1	Phytic acid	Milling, soaking, germination, fermentation, blanching	Soaking, germination, fermentation
2	Lectins	Milling, boiling, soaking, fermentation	Soaking, boiling, heating, fermentation
3	Tannins	Milling, soaking, autoclave, germination, fermentation, blanching, boiling	Boiling, soaking
4	Saponins	Boiling, washing, fermentation, roasting	Fermentation
5	Oxalic acid	Milling, blanching, boiling, soaking	Boiling, soaking
6	Enzyme inhibitors	Soaking, autoclave, roasting, fermentation, boiling	Fermentation, boiling
7	Polyphenols	Germination, soaking, fermentation	Germination
8	Gossypols	Extrusion, fermentation	Extrusion
9	Raffinose	De-hulling, germination, alcoholic extraction, microbial treatment	Cooking
10	Goitrogens	Steaming, cooking, fermenting, milling, soaking, washing	Soaking
11	β-N-oxalyl amino alanine	Soaking, boiling, fermentation, cooking, autoclaving	Soaking and cooking
12	Alkaloids	Soaking, washing, germination, fermentation, aqueous thermal treatment alkaline treatment	Soaking, cooking fermentation and alkaline treatment

Fermentation: Fermentation is a metabolic process known for its ability to enhance the nutritional quality and digestibility of grains. During fermentation, carbohydrates undergo oxidation to produce energy, which is essential for metabolic activities. Studies have demonstrated that fermentation significantly improves the nutritional profile of grains by increasing the bioavailability of essential nutrients such as lysine, methionine and tryptophan [24]. These critical amino acids are significant for various physiological functions in the human body, including protein synthesis and immune function. One of the notable benefits of fermentation is its ability to reduce the levels of anti-nutrients present in cereals. Anti-nutrients like phytic acid, tannins and polyphenols can interfere with the absorption of minerals and proteins in the digestive system. Fermentation processes, particularly those involving Lactic Acid Bacteria (LAB), have been shown to significantly decrease the concentrations of these anti-nutrients in grains. For example, lactic acid fermentation has been effective in reducing tannin levels, thereby enhancing the absorption of iron from cereals [25]. Recent research has explored various fermentation techniques to optimize the reduction of anti-nutritional components in maize flour. Studies have demonstrated that prolonged fermentation periods with LAB mixture result in greater reductions of anti-nutrients such as tannins, polyphenols, phytate and trypsin inhibitors compared to spontaneous fermentation methods. This highlights the effectiveness of controlled fermentation processes in enhancing the nutritional quality of fermented foods. Overall, fermentation not only improves the digestibility and bioavailability of nutrients in grains but also contributes to reducing the adverse effects of anti-nutrients. By breaking down complex compounds and enhancing nutrient absorption, fermentation plays a significant role in promoting the nutritional value and health benefits of fermented grain products. Incorporating fermentation into food processing practices offers a sustainable approach to improving the nutritional quality of staple foods and enhancing overall dietary health.

Milling: Milling is a widely employed technique in grain processing, primarily aimed at separating the outer bran layer from the grains. This process is instrumental in reducing the concentration and distribution of anti-nutritional factors, which are predominantly located in the bran layers of grains. By removing the bran, milling effectively eliminates various anti-nutrients such as phytic acid, lectins, tannins and enzyme inhibitors from the grain matrix [12]. These anti-nutrients can impair the absorption of essential nutrients and minerals in the human digestive system, thus affecting overall nutritional quality. Study focusing on pearl millet has highlighted the transformative impact of milling on the chemical composition and distribution of oxalic acid within the grain structure. Oxalic acid, known for its potential to bind with minerals and form insoluble complexes, is notably affected by the milling process, which alters its presence in the aleurone layer and bran of grains. Consequently, milling not only enhances the nutritional value of grains by reducing anti-nutrients but also contributes to improving their digestibility and bioavailability. The effectiveness of milling lies in its ability to physically separate the outer layers of grains, where anti-nutrients tend to accumulate, from the inner endosperm, which is richer in starch and protein content. By removing the bran layers, milling significantly diminishes the concentration of substances that can hinder nutrient absorption and utilization in the body. This process is significant for enhancing the nutritional quality of grains intended for human consumption, particularly in regions where cereals and millets form staple foods. Milling represents a pivotal step in grain processing that not only refines the texture and appearance of grains but also plays a vital role in improving their nutritional profile by reducing anti-nutritional factors. The widespread adoption of milling in food processing industries underscores its importance in ensuring that grains provide optimal nutritional benefits without compromising dietary health.

Soaking: Soaking is a widely employed method for mitigating the presence of anti-nutrients in foods, particularly in nuts, grains and edible seeds. This process involves immersing the food in water for a specified period, which facilitates several beneficial changes. Firstly, soaking enhances the moisture content essential for the activation of endogenous phytases present in plant foods, which are enzymes responsible for breaking down phytic acid [26]. Phytic acid is known for its ability to chelate minerals, thereby reducing their bioavailability in the body. By activating phytases through soaking, the breakdown of phytic acid is promoted, consequently improving the digestibility and nutrient absorption of grains. Studies have demonstrated that soaking effectively reduces various other anti-nutrients as well. For instance, soaking legumes overnight has been found to decrease the levels of phytate, protease inhibitors, lectins and tannins. Research indicates that soaking seeds for 24 hours can significantly lower hydrogen cyanide content, an important consideration for enhancing food safety and nutritional quality. Additionally, soaking treatments have been shown to reduce stachyose and raffinose content, which are oligosaccharides known for causing flatulence and digestive discomfort. The duration of soaking plays a significant role in its effectiveness. For instance, soaking peas for 12 hours can reduce phytate content by up to 9%, while soaking pigeon peas for 6-18 hours can lead to substantial reductions in lectins, tannins and protease inhibitors. Moreover, soaking grains like wheat and barley for 12-24 hours has been recommended to enhance their nutritional value by increasing protein and mineral content.

Sprouting: Sprouting is a highly effective method utilized to diminish the levels of anti-nutrients present in plant-based foods. This process involves the germination of seeds, during which various anti-nutrients such as phytate and protease inhibitors undergo degradation. Studies have demonstrated significant reductions in phytate levels ranging from 37% to 81% following sprouting, attributed to the activation of phytase enzymes that break down the phytate-mineral complexes in grains. This enzymatic activity is particularly significant in enhancing the bioavailability of minerals like calcium, iron and zinc in sprouted grains. Additionally, sprouting has been observed to reduce lectin and protease inhibitor content, although the decreases may vary depending on the specific type of grain or legume. Research documented substantial reductions in phytate levels in cereal grains after 10 days of sprouting, underscoring the effectiveness of this method in enhancing nutritional quality. Moreover, sprouting has been linked to alterations in the profile of bioactive compounds such as isoflavones in soybeans, which can contribute to their nutritional benefits [27]. Furthermore, sprouting appears to be particularly advantageous in reducing polyphenol concentrations in millets, with studies reporting reductions of up to 75%. This surpasses the decreases achieved by other processing methods such as soaking, microwave treatment and fermentation, highlighting sprouting as a superior technique for enhancing the overall nutritional value of grains.

Extrusion: Extrusion is a highly valued processing technique in the food industry due to its wide application and numerous advantages. This method involves pushing food ingredients through a small opening using either a single screw or a series of screws. Research has consistently shown that extrusion is remarkably effective in reducing the levels of anti-nutrients present in foods, including phytic acid, tannins, phenols, alpha-amylase inhibitors and trypsin inhibitors. Specifically, extrusion has been noted for its ability to decrease the ratio of phytic acid phosphorus to total phosphorus in processed foods. Studies have highlighted the significant benefits of extrusion in enhancing the nutritional quality of legumes, particularly when they are pre-soaked in water for 16 hours prior to extrusion. This process not only improves the digestibility of legumes but also enhances their utilization by both humans and animals. For instance, the extrusion of sesame oilseed meal using a single-screw frying extruder has been shown to effectively reduce the content of tannins, thereby improving its nutritional suitability. Moreover, extrusion has been instrumental in reducing free gossypol levels in various food products. According to test results conducted under the standards of the American Oil Chemists' Society, extrusion has achieved significant reductions ranging from 71% to 78% in free gossypol levels, underscoring its effectiveness in improving the safety and nutritional value of gossypol-containing foods [28].

DISCUSSION

Breeding strategies to alter anti-nutritional components for enhanced nutrient bioavailability in foods

The reduction of anti-nutrients in crops is a pivotal breeding strategy that significantly enhances the quality of produce. Various breeding techniques, including selection, mutation, backcrossing, hybridization and population improvement, have been employed using natural and induced genetic resources. The breeding for reducing anti-nutrients in crops began in the early 1960s with the development of glandless cotton. More recently, gene silencing and editing techniques have been used to create low anti-nutrient lines of major crops. Conventional breeding for reducing anti-nutrient content started with identifying germplasm accessions that naturally accumulated fewer anti-nutrients. For instance, in 1960, reduced gossypol content in cotton was selected, revealing that glandlessness is controlled by two genes. This discovery eventually led to the development of genotypes with glandless seeds but glanded plants, effectively reducing gossypol in seeds while

maintaining it in vegetative parts. In soybean, lines with zero Kunitz inhibitors were identified, controlled by a recessive gene which was later introduced into elite cultivars. Similarly, low vicine and covicine lines were selected from faba bean germplasm, with these traits also governed by recessive genes. Recurrent selection in maize, involving synthetic populations, successfully developed high-iron and high-zinc lines with low phytic acid. In quinoa, pedigree breeding reduced saponin accumulation, although dominance of the trait required alternate strategies. Induced mutations, such as those in soybean using gamma rays, produced mutants with lower lectin content and normal germination rates, suggesting potential donors for improving meal quality. Backcrossing and mutation breeding are predominant strategies to reduce anti-nutritional traits in crops. These traits often play significant roles in plant defense and stress tolerance, so their reduction can negatively impact yield. For example, reducing phytic acid in crops through identified mutants resulted in improved nutrient bioavailability. Marker-assisted backcrossing has been employed to introduce low-phytic acid traits into elite cultivars, with near-isogenic lines demonstrating reduced phytate content without other morphological changes [29-33].

Gene silencing using RNAi technology offers an efficient way to optimize anti-nutrient expression in crops. For instance, ultra-low-gossypol cotton was developed by silencing the d-cadinene synthase gene, reducing gossypol accumulation in seeds and vegetative parts. This approach has been patented and shown to improve yield and fiber quality. Similarly, metabolite engineering reduced raffinose levels in soybean, enhancing its nutritional value for poultry. Advanced gene editing techniques, such as Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR-Cas9), have been employed to reduce anti-nutrients. For example, knocking out specific genes in soybean reduced raffinose content without affecting plant growth. RNAi-mediated silencing of multiple genes in wheat revealed increased trypsin inhibition, beneficial for non-celiac wheat-allergic patients [34]. Manipulating anti-nutritional traits involves careful consideration of their roles in plants. For instance, trypsin inhibitors provide defense against pests but hinder digestion in humans. Advanced gene editing offers potential solutions, focusing on seed-specific reduction to maintain plant defense mechanisms while enhancing food quality. Traditional breeding has also addressed glucosinolate content in *Brassicas*. High-density genetic mapping and comparative genomics identified significant Quantitative Trait Loci (QTLs) for glucosinolate biosynthesis, leading to the development of crops with altered glucosinolate profiles. For instance, high-glucoraphanin broccoli was developed through marker-assisted selection. Similar strategies have been applied to radish and other crops, identifying candidate genes for glucosinolate synthesis. Breeding efforts have also focused on reducing erucic acid in *Brassicas* due to its health risks [35-38]. Mutations in the Fatty Acid Elongase 1 (*FAE1*) gene were induced to produce low-erucic acid lines, which were then introgressed into elite cultivars. Advanced progenies showed improved morphological traits, suggesting effective recombination and reduction of negative pleiotropic effects. Marker-assisted breeding and QTL detection have played significant roles in reducing anti-nutrients in crops. Genetic manipulation of these traits requires monitoring to avoid negative impacts on plant defense and stress tolerance. Integrative omics and advanced bioinformatics tools are essential for further reducing anti-nutrients without compromising yield. Gene silencing using RNAi technology has been effective in reducing anti-nutrients in major crops. For example, RNAi-mediated silencing of genes involved in phytic acid biosynthesis in rice and *Brassicas* has successfully reduced phytic acid content. CRISPR-Cas9 has been used to edit similar genes in soybean, resulting in stable transgenic lines with altered phytate concentrations. Future research should focus on integrating traditional processing methods with modern technologies to enhance food safety and nutritional quality [39]. Traditional methods such as soaking, germination, boiling and fermentation have been effective in reducing anti-nutritional factors like phytic acid, lectins, tannins and enzyme inhibitors. These methods improve nutrient bioavailability and preserve the sensory qualities of foods. Innovative food processing technologies, such as extrusion, complement traditional methods by offering efficient and scalable solutions. Extrusion reduces levels of anti-nutrients through the application of heat and pressure, enhancing the safety and nutritional suitability of food products. The combination of traditional wisdom and modern scientific advancements is significant for addressing global nutrition challenges. Education and awareness initiatives are essential to inform consumers, food producers and policymakers about the benefits of processed foods that retain nutritional integrity. Supporting research and development in food processing technologies can further optimize these methods for maximum efficacy and sustainability. Efforts should also focus on promoting the adoption of improved food processing methods across different food systems and regions [40-42]. By integrating traditional and innovative approaches, stakeholders can ensure that processed foods meet safety standards and consumer expectations while retaining high nutritional value. Overall, the reduction of anti-nutrients in crops through breeding and advanced processing techniques is essential for improving nutrient bioavailability and addressing global malnutrition. Continued innovation and education are necessary to promote these methods and ensure better health and nutrition for populations worldwide [43].

CONCLUSION

The presence of anti-nutritional factors in plant-based foods poses health risks, but effective processing methods offer solutions to mitigate these issues. Traditional techniques like soaking, germination, boiling and fermentation, practiced for centuries, significantly reduce anti-nutrient levels, enhancing nutrient absorption and preserving cultural diets. Innovative technologies like extrusion complement these methods by providing scalable solutions to further lower anti-nutrient content, improving the safety and nutritional quality of foods. Research highlights that integrating traditional wisdom with modern advancements is essential for addressing global nutrition challenges, particularly in vulnerable populations. Promoting the adoption of these processing methods, supported by education and research, can optimize food safety and nutritional integrity across diverse food systems. This approach ensures that processed foods meet both safety standards and consumer expectations while contributing to improved global dietary health.

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REVIEW ARTICLE

Innovations and strategies in post-harvest handling and value addition of horticultural produce

Ravi Kishan Soni*, Gajanand Modi

Soni RK, Modi G. Innovations and strategies in post-harvest handling and value addition of horticultural produce. AGBIR.2024;40(4):1206-1209.

Horticultural production is reaching new heights every year, with India being the second-largest vegetable producer globally after China. Despite this, significant postharvest losses occur due to improper management and handling, exacerbating global challenges of food security, hunger, malnutrition and climate change. The United Nations' Sustainable Development Goal 2 aims to reduce food losses by 50% by 2030. This review highlights strategies to enhance the storability of fresh vegetables, including value addition through drying technology, temperature and storage atmosphere control and the use of anti-senescent molecules such as salicylic acid, nitric oxide, 1-methylcyclopropene and methyl jasmonate. In India, horticulture contributes 30% to agricultural Gross Domestic Product (GDP) from 8.5% of the cropped area, with a significant portion of produce being fruits and vegetables. Effective postharvest management and value addition can transform waste into wealth, reduce production costs and optimize biomass utilization. Technologies like drying, dehydration, freezing, fermentation and extraction are essential for recycling and upgrading vegetable market waste. This review provides a comprehensive overview of postharvest losses and potential strategies for reducing losses in vegetables, emphasizing the need for cost-effective technologies tailored to Indian conditions.

Key Words: *Horticulture; Post harvest management; Post harvest losses; Value addition; Biomass*

INTRODUCTION

The horticultural sector holds significant potential for the development of wastelands through well-planned system. Compared to traditional food crops, horticultural crops require comparatively less water, provide higher employment opportunities and are more environment-friendly. From the perspective of nutritional security, fruits and vegetables be prominent due to their potential for value addition, which not only enhances their market value but also contributes substantially to foreign exchange earnings. The horticultural crops are thus not only agricultural products but pivotal commodities in commerce, having gained substantial market potential globally. In the context of the Indian agricultural economy, horticultural crops have a significant role, contributing approximately 30% to the GDP from just 11.73% of the total arable land area. This sector is second only to China in terms of production, making India one of the leading producers of fruits and vegetables globally. In 2012, India's food processing industry was valued at around $ 70 billion, with the country producing 257 million tons of food grains, 75 million tons of fruits and 149 million tons of vegetables. Despite this strong production, India faces significant challenges with post-harvest losses, which are alarmingly high, vary from 30% to 40% for fruits and vegetables. This clearly contrasts with the lower post-harvest losses observed in countries like the United States of America and China, highlighting the urgent need for improved post-harvest management and value addition systems in India [1]. The high rate of post-harvest losses in India can be attributed to various factors, including inadequate infrastructure, inefficient supply chains and insufficient processing facilities. These losses not only reduce the net availability of produce but also represent a significant economic drain, estimated at Rs. 23,000 crores annually. The Swaminathan Committee reported that post-harvest handling accounts for 20%-30% of losses at different stages, including storage, grading, packing, transport and marketing. Furthermore, according to Chadha, India loses about 35%-45% of harvested fruits and vegetables during handling and storage, leading to annual losses of Rs. 40,000 crores [2]. The specific post-harvest losses for various fruits and vegetables further illustrate the severity of the issue: papaya (40%), grapes (27%), banana (20%-28%), citrus (20%-95%), avocado (43%) and apple (14%). Similarly, vegetable losses include onion (25%-40%), garlic (8%-22%), potato (30%-40%), tomato (5%-47%), cabbage and cauliflower (7.08%-25%), chili (4%-35%), radish (3%-5%) and carrot (5%-9%).

Despite these challenges, there are potential opportunities for enhancing the value of horticultural produce through various post-harvest technologies and practices. The diverse group of vegetables produced in India offers significant nutritional and health benefits, including essential vitamins, minerals and dietary fiber. These nutritional benefits are complemented by the presence of various phytochemicals that help in maintaining good health and preventing numerous diseases. Specific vegetable families such as cucurbits (e.g. bottle gourd, bitter gourd, cucumber), solanaceous vegetables (e.g. tomato, brinjal, chili), leguminous vegetables (e.g. Indian bean, French bean, pea), leafy vegetables (e.g. spinach, amaranth, fenugreek), cruciferous vegetables (e.g. cauliflower, cabbage, broccoli) and umbelliferae (e.g. carrot) are powerhouses of these beneficial compounds. To address post-harvest losses and enhance the value addition of horticultural produce, various drying technologies have been explored. Techniques such as hot air-controlled drying, spray drying, freeze drying, infrared drying, superheated steam drying, osmotic dehydration, microwave drying and hybrid drying methods are among the most notable. Freeze drying, although producing the best quality dried produce, has limitations such as longer drying times and higher energy consumption, making it cost-prohibitive for large-scale operations. On the other hand, hot air drying is widely used due to its cost-efficiency and ease of handling, although it may not always preserve the quality of the produce as effectively as freeze drying [3]. Moreover, several innovative post-harvest technologies have been developed to increase the shelf life of fresh produce. These include minimal processing, edible coatings, modified atmosphere packaging, ethylene absorbents, essential oils and hurdle technology. Other advanced methods involve the use of 1-methylcyclopropene, polyamines, salicylic acid, nitric oxide, 6-benzylaminopurine, methyl jasmonate and other anti-senescent molecules, all of which have shown in extending the freshness and shelf life of vegetables [4,5]. The commercial potential of vegetable-based processed products is immense, driven by their taste, health and nutritional benefits. The Indian Council of Agricultural Research (ICAR)-Indian Institute of Vegetable Research (IIVR) at Varanasi has been at the forefront of developing various vegetable-based processed products such as green chili powder, dehydrated okra, bitter gourd chips, instant bottle gourd kheer mix, instant moringa soup mix and instant moringa drink mix. These innovations have been patented and commercialized, providing a viable solution to reduce post-harvest losses and wastage. These developments underscore the need for a greater focus on secondary agriculture to increase employment,

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income and reduce losses, thereby promoting self-reliance and supporting agricultural start-ups [6].

Despite these advancements, a significant gap remains between the gross production of fruits and vegetables and their net availability due to post-harvest losses. The reasons for these losses are multifaceted, encompassing poor facilities, inadequate management, market dysfunctions and occasional carelessness by farmers. Therefore, it is essential to address these issues comprehensively to enhance the efficiency of the supply chain and improve the overall post-harvest management system. The present study aims to explore and discuss the critical issues related to post-harvest management of fruits and vegetables in India, with a particular focus on value addition. By reviewing existing literature and assessing the current state of post-harvest technologies and practices, this study seeks to provide actionable insights and recommendations to reduce post-harvest losses and enhance the value addition of horticultural produce. Such efforts are important for improving the economic viability of horticultural farming, ensuring better nutritional security and contributing to the sustainable development of the agricultural sector in India.

LITERATURE REVIEW

Losses after harvesting

Fruits and vegetables, characterized by their high moisture content, tender texture and high perishability, present a unique set of challenges in post-harvest management. If not handled properly, these highly nutritious products can deteriorate and become rotten within a matter of days or even hours. In the agricultural economy, horticultural crops are not only vital for nutritional security but also generate significant cash income for growers compared to cereals and pulses. The natural respiration process in these crops involves the crisis of food reserves and the aging of these organs, leading to their rapid decline if post-harvest practices are inadequate. Mechanical injuries are a major concern due to the tender texture and high moisture content of fruits and vegetables. Poor handling, unsuitable containers, improper packaging and transportation can easily cause bruising, cutting, breaking and other forms of mechanical injury. These damages significantly reduce the storability and market value of the produce. Physiological deterioration also plays a critical role post-harvest, as the cells of fruits and vegetables remain active and continue their physiological activities. This can lead to disorders caused by mineral deficiencies, temperature injuries or undesirable atmospheric conditions such as high humidity. Enzymatic actions further exacerbate physiological deterioration, resulting in over-ripeness and senescence. The importance of proper harvesting techniques cannot be overstated. Vegetables must be harvested at the correct maturity stage to achieve maximum quality. Harvesting at either pre-maturity or post-maturity stages, coupled with improper handling methods, significantly increases losses. Rough handling during and after harvest often results in mechanical injuries such as bruising, scarring, scuffing, cutting or puncturing the vegetables, thereby lowering their storability and quality. Post-harvest processing typically includes harvesting, sorting, grading and washing. The types of packaging materials used and the methods of transportation play critical roles in determining the extent of post-harvest losses. Farmers often use wooden baskets, gunny bags and plastic crates for packaging, with mini-trucks or lorries being common modes of transport. However, the increased use of corrugated cartons, especially ventilated Corrugated Fiberboard (CFB) boxes, for local distribution has been found to reduce bruising and other mechanical injuries, thereby preserving the quality of the vegetables [7].

Storage conditions also have a significant impact on the longevity of stored vegetables. Optimal storage temperatures can slow down aging, softening, color changes, undesirable metabolic shifts, moisture loss and pathogen-related losses. On-farm storage is particularly critical in remote and inaccessible areas of India, where high perishable vegetables are prone to losses. Proper cold chain management, which includes immediate cooling after harvest and maintenance during transport, is essential. However, the lack of cold storage facilities, coupled with the high cost and energy requirements of refrigeration, poses significant challenges. To address this, low-cost, zero-energy, environmentally friendly cool chambers, such as the Pusa Zero Energy Cool Chamber (Pusa ZECC), have been fabricated from locally available materials and operate on the principle of evaporative cooling. The issue of post-harvest losses is a serious concern for India's agricultural sector, particularly given the highly perishable nature of vegetables. Losses occur due to insufficient methods of harvest, decay, over-ripening, mechanical injury, weight loss, trimming and sprouting. Addressing these aspects is critical for improving the vegetable industry, especially in the context of processing and marketing [8]. Poor planning and lack of market information can lead to overproduction, which in turn results in unsold produce due to inadequate transportation and storage facilities. Additionally, improper preservation methods at home, such as methods of cooking and preparation like peeling, also contribute to these losses. Fruits and vegetables are rich sources of vitamins and minerals essential for human nutrition. However, the loss of these nutritious foods during transit from harvest to consumer represents a significant loss in valuable food quantity. In developing countries, up to 23% of perishable foods spoil due to inadequate cooling. Proper storage temperature management can improve time management and allow for leisurely marketing and consumption. In developed countries, maintaining cold storage temperatures, coupled with relative humidity throughout the entire supply chain from farm to consumer, significantly extends the shelf life of vegetables [9]. Conversely, inadequate storage facilities in developing countries remain a primary cause of post-harvest losses. Transportation presents another significant challenge, especially in the context of globalized food trade. Long-distance transportation with poor refrigerated facilities can lead to substantial losses in both quality and quantity, particularly for fresh produce. Developed countries typically employ refrigerated vehicles for perishable food delivery, whereas inadequate transport and inefficient logistics in developing nations hinder proper preservation. Furthermore, vegetables often suffer from inadequate packaging and careless loading practices, sometimes being haphazardly tossed into vehicles. Effective packaging and refrigerated transport significantly reduce losses and extend shelf life. Studies in Sub-Saharan Africa and South Asia highlight concerning statistics, with 46% of horticultural crops packed in cloth bundles or large sacks, 31% in open baskets and 8% having no packaging at all. At the retail stage, the absence of proper packaging further shortens the shelf life of vegetables, necessitating quick sales. Major challenges include cold chain management, the non-availability of mechanized sorting/grading facilities, the lack of varieties suitable for processing and inefficiencies in the complete value chain of vegetables [10]. The consumption stage, from purchasing to actual consumption is another phase where significant losses occur. Nearly half of household food waste consists of fruits and vegetables. Studies from the Food and Agriculture Organization (FAO) suggest that fruit and vegetable waste constitutes around 39%-40% of total household waste. Reasons for consumer waste vary from over-purchasing and poor planning to inadequate home-storage management. Socio-cultural factors such as gender, lifestyle, income and the availability of home storage facilities also influence the extent of waste [11].

Post-harvest losses in developed nations are often linked to consumer preferences, especially stringent quality standards and safety requirements for fruits and vegetables [12]. These losses are significant not only in quantitative terms but also from the perspective of quality nutrition. Careless harvesting and rough handling of perishable produce can result in bruising and scarring, reducing the quality and market price. Damaged produce also fails to attract international buyers, resulting in economic losses and a tarnished reputation for the exporting country. This degradation in both quantity and quality of food production from harvest to consumption impacts the nutrient/caloric composition, acceptability and edibility of the products. To improve the situation, it is essential to create awareness among growers, farm workers, managers, traders and exporters about the extent of losses being incurred and their economic consequences. These stakeholders need to learn the basic principles of fruit handling and storage. With increasing consumer consciousness about health and nutrition, there is a growing tendency to avoid chemicals and synthetic foods in favor of natural resources. Underutilized fruits such as aonla, bael, jamun, karonda, passion fruit, phalsa, pomegranate, pumpkin, tamarind and wood apple play an essential role in overcoming malnutrition and provide a primary livelihood source for the poor.

Mitigating post-harvest losses in horticulture: Strategies and innovations

The significant issue of post-harvest losses in the vegetable supply chain presents a multifaceted challenge impacting food security, economic stability and the livelihood of farmers globally, particularly in developing countries like India. Effective post-harvest management, encompassing a wide array of activities such as cleaning, washing, sorting, grading, disinfecting, packaging and storage at optimum temperatures, is critical for preserving the edible and nutritional quality of vegetables for extended periods. This approach

not only supports the sustenance of farmers but also enhances the overall efficiency of the food supply chain [13].

Post-harvest management activities

Post-harvest management involves several key processes. Sorting and grading are vital steps where diseased, damaged, over-mature, insect-infested and rotten vegetables are removed, ensuring only high-quality produce reaches consumers. Standardized grading criteria further enhance product consistency, improving market positioning and consumer trust. Washing vegetables eliminates contaminants such as dirt, dust, insects, mold and any residual sprays, thus enhancing their appearance and hygiene. The application of chlorinated water (100-150 ppm) or saltwater (1%-2%) can effectively reduce surface contaminants. Disinfectants like chlorinated water at pH 6.5-7.5 are employed to control inoculum in packing houses during storage [14,15].

Packaging of vegetables

In India, fresh vegetables are typically packaged and transported in perforated plastic crates, gunny bags and bamboo baskets. Softer vegetables often require cushioning with dry grass, banana leaves or paper shreds to prevent damage. Consumer packages may include plastic bags and shrink wraps with or without consumer trays, usually made of foam or plastic. Advanced packaging materials, such as plastic films and waxed liners, provide additional protection. Packaging is generally categorized into consumer units or pre-packaging, transport packaging and unit load packaging or pallets.

DISCUSSION

Challenges with specific vegetables

Broccoli for instance, has a limited shelf life due to its high respiration rates, leading to quick degradation of chlorophyll, flower bud opening, loss of turgidity, off-flavor development and nutritional quality loss. However, the use of Flexfresh™ packaging material, which creates a modified atmosphere during storage at 3°C, has been shown to extend the shelf life of broccoli florets to 49 days. Similarly, capsicum stored in Flexfresh™ expanded polyethylene biopolymer pouches saw increased shelf life and acceptability. Bitter gourd fruits packed in corrugated fiberboard boxes with potassium permanganate sachets exhibited the lowest degradation in fruit quality over an 8-day storage period at room temperature.

Edible coatings

Edible coatings, such as chitosan, cellulose, starch, gums, beeswax and protein-based coatings like gelatin and soy proteins, offer another layer of protection. These coatings reduce moisture loss, slow down respiration, senescence and enzyme activity, preserve natural color, flavor and texture and protect against microbial growth. Application methods include spraying, dipping, smearing or brushing directly onto the vegetable surface, followed by drying to form a protective layer. The efficacy of these coatings depends on various factors, including the materials used, temperature, thickness and type of vegetable. Approved edible coatings enhance shelf life and maintain the quality of various vegetables, including tomatoes, cucumbers and eggplants [16].

1-methylcyclopropene

1-Methylcyclopropene (1-MCP) is an ethylene antagonist that delays natural ripening and aging processes in vegetables. By binding to ethylene receptors, 1-MCP blocks the signaling responsible for ripening, thereby extending the shelf life of produce like cucumbers, tomatoes and peppers. It is recognized for use in over 50 countries and can be applied through various methods, including gaseous treatment, fumigation and aqueous solution dipping.

Value addition

Value addition through drying offers significant opportunities for vegetable preservation. Despite potential innovation and diversification in the vegetable sector, many Small and Medium Enterprises (SMEs) struggle with upscaling, technology access and compliance with international standards. Traditional processing methods, such as drying, can transform perishable vegetables into shelf-stable products, creating new market opportunities and fostering entrepreneurship. For instance, drying techniques can be applied to vegetables like bitter gourd, cauliflower, carrot and broccoli, yielding high-quality, value-added products [1].

Minimal processing

Minimal processing techniques for fresh-cut vegetables are popular due to their fresh-like characteristics, safety and quality. These techniques include cleaning, trimming, slicing, shredding, dicing, sanitizing and packaging. However, processing can cause tissue damage, hasten microbial growth and spoilage, necessitating rigorous sanitation and careful process hygiene. Maintaining a consistent cold chain and employing preservation techniques like chemical preservatives, mild heat treatment and vacuum packaging are significant for minimal processing.

Drying techniques

Drying is a cost-effective method for producing shelf-stable products. Techniques such as solar drying, osmotic dehydration, microwave drying and freeze drying offer various benefits. For instance, osmotic dehydration uses hypertonic solutions for partial moisture removal, resulting in effective drying and rehydration with low energy consumption and high product quality. Microwave drying provides quick and uniform drying, while freeze drying retains maximum quality in the final product but consumes significant energy. These techniques can significantly reduce post-harvest losses and ensure nutritional security [17].

Ready-to-eat convenience products

The demand for ready-to-eat convenience products is growing due to lifestyle changes and increased awareness of health foods. Products like bitter gourd chips and instant bottle gourd kheer mix offer innovative solutions to post-harvest loss while providing consumers with nutritious and convenient options. ICAR-IIVR has developed several vegetable-based convenience products that can be stored for extended periods and reconstituted quickly, addressing both post-harvest losses and consumer needs [1].

The future of post-harvest management and value addition

The future of post-harvest management and value addition in vegetables looks potential for enhancing food security, economic growth and agricultural sustainability. Processing techniques such as freezing, drying and fermentation can transform perishable vegetables into long-lasting products. Investment in research and development, improved infrastructure and innovative processing methods are key to unlocking the full potential of value addition in vegetable crops. These advancements will contribute to economic development, self-reliance and the growing demand for nutritious and high-quality produce.

CONCLUSION

The current scenario underscores significant challenges in post-harvest management and the underutilization of value-addition techniques. However, the potential for innovation and market diversification is vast. Effective post-harvest management and value addition can reduce food wastage, enhance the economic value of vegetables and create new market opportunities. Collaborative efforts in research, technology and policy support are essential to realizing these prospects. By harnessing these opportunities, the agricultural sector can achieve improved sustainability, economic viability for farmers and enriched consumer choices, ensuring a brighter future for vegetable crop management. This introduction sets the stage for a comprehensive exploration of post-harvest management and value addition in vegetables, emphasizing the need for innovative approaches to enhance food security, economic stability and sustainability in agriculture.

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REVIEW ARTICLE

Exploring India's angiosperm diversity: A comprehensive review

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Modi G, Soni RK. Exploring India's angiosperm diversity: A comprehensive review. AGBIR.2024;40(4):1214-1217.

India's remarkable botanical legacy is exemplified by its vast array of angiosperms or flowering plants, thriving within its multifaceted landscapes. This extensive review begins on a thorough exploration of the nation's angiosperm diversity, scrutinizing their distribution, ecological contributions and evolutionary heritage across various ecosystems. By integrating a wealth of existing literature, historical narratives and recent scientific advances, the study provides a nuanced and comprehensive portrayal of India's angiosperm flora.

The review places particular emphasis on endemic species and their conservation status, as well as their integral roles in traditional medicine and cultural practices. Additionally, it investigates the hurdles and prospects for safeguarding India's angiosperm diversity, considering the impacts of habitat degradation, climate change and anthropogenic pressures. By underscoring the critical importance of preserving this botanical treasure trove, the review highlights the pressing need for ongoing research and strong conservation initiatives to protect the ecological balance and cultural heritage of this biodiverse hotspot.

Key Words: *Angiosperm; Biodiversity; Forest; Plant species*

INTRODUCTION

India boasts a rich blend of biological and cultural diversity, standing as one of the 17 mega-biodiverse nations worldwide. Its landscape is inhabited by a plethora of tribal, nomadic, farming and fishing communities, each holding unique nature-based livelihoods and a wealth of traditional knowledge. In contemporary times, the utilization of traditional knowledge has expanded beyond the day-to-day activities of these communities. There is a rising international appetite for natural, herbal and organic products crafted through traditional methods, fueling the growth of industries such as herbal medicine, cosmetics and personal care.

This expanding market demand for bio-resources and associated traditional knowledge presents indigenous and local communities with fresh methods for income generation and economic empowerment. However, the surge in biopiracy and the unprincipled use of traditional knowledge has become a growing concern. The chief factor behind this misappropriation is the unregulated access to traditional knowledge within local communities and the absence of adequate documentation of this invaluable resource [1].

India is a treasure trove of biodiversity, presenting an extraordinary range of ecosystems that span the country's varied topography. The great Himalayan ranges, capped in eternal snow, give way to lush sea-level plains, meandering lowland swamps and complex mangrove networks. This diverse landscape also includes dense tropical rainforests, fertile alluvial plains, vast arid deserts and cold, high-altitude deserts.

The nation's climate is equally diverse, with tropical and subtropical zones characterizing the Indo-Gangetic plains and the Peninsular region, while the northern reaches of the country experience temperate to arctic conditions across the expansive Himalayan region.

These rich biogeographic and climatic conditions cement India's reputation as a global hotspot of biodiversity, emphasizing the critical need for conservation initiatives. Safeguarding this unique ecological heritage is imperative for preserving the wealth of plant and animal life that inhabits these varied ecosystems.

LITERATURE REVIEW

Biogeographically, India is a unique convergence of two major areas-the Palearctic and Indo-Malayan and encompasses five principal forest biomes: Tropical evergreen and semi-evergreen forests, tropical deciduous forests, tropical thorn forests, montane forests and littoral and swamp forests. Reflecting the vast diversity across its landscapes, Balakrishnan delineates the country into eleven phytogeographic zones such as: North-West Himalayas; Indo-Gangetic Plains; Eastern Himalayas (Arunachal Pradesh and Sikkim); Assam (North-Eastern India excluding Arunachal Pradesh and North Bengal); Central India; Arid zone; Northern Western Ghats and northern West Coast; Southern Western Ghats, southern West Coast and Lakshadweep; Deccan; Eastern Ghats and Coromandel coast and Andaman and Nicobar Islands [2]. India, with a geographical expanse of approximately 3,287,263 Km^2, ranks as the world's seventh-largest country. It spans from latitudes 8°4'N to 37°6'N and longitudes 68°7' E to 97°25'E. The nation's forest cover has been estimated at 7,13,789 km^2, constituting 21.71% of its total geographic area. This encompasses 99,779 km^2 of very dense forest, 306,890 km^2 of moderately dense forest, 307,120 km^2 of open forest and 46,539 km^2 of scrubland (Forest Survey of India Report, 2021-22). India's varied topography and climate nurture rich ecological zones and complex forest ecosystems, underscoring the importance of preserving its abundant natural resources and extensive biodiversity.

India is rich in biological diversity largely due to its prevailing varied physical environment, latitude, altitude, geology and climate. Observing the country's rich plant diversity, Hooker commented that 'The Flora of British India is more varied than that of any other country of equal area in the eastern hemisphere, if not on the globe' [3]. The Indian flora represents taxa occurring in different countries including Afghanistan, Bhutan, Bangladesh, China, Nepal, Pakistan, Myanmar, Malaysia, Indonesia, Thailand, Vietnam, Laos and Cambodia. There are even the representatives from African, American, Australian and European countries. Though the geographical area cover of India represents only about 2.4% of the world's total landmass, the country harbours collectively a total of 55,048 taxa belonging to 21,984 angiosperms, 82 gymnosperms, 1314 pteridophytes, 2800 bryophytes, 2989 lichens, 15602 fungi, 9008 algae and 1269 microbes representing approximately 11.4% of total so far recorded species of the world and about 25% of vascular plants that occur in India are endemic to the country [4].

India's floral diversity is predominantly centered around four globally recognized biodiversity hotspots: The Himalayas, Western Ghats and Sri Lanka, Northeast India and the Andaman Islands (Indo-Burma) and the Nicobar Islands (Sundaland). These hotspots are among the 36 recognized worldwide and hold an exceptional concentration of endemic plant species. However, these regions also face significant challenges such as habitat loss and a high incidence of threatened plant species.

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In total, India is home to 4,303 flowering plant taxa across 977 genera in 154 families, deemed to be strictly endemic within the country's current political borders. The endemic flora is dominated by dicotyledons, comprising 3,170 taxa (72%) spread across 723 genera from 127 families. In contrast, monocotyledons contribute 1,133 taxa (26%) from 254 genera in 27 families.

Estimates suggest that approximately 10% of India's flowering plant species are under threat of extinction. This calls for heightened conservation efforts to protect the nation's vast and precious floral heritage, which plays an important role in maintaining ecological balance and supporting local biodiversity.

Northeast India, with its rich botanical heritage, stands as a cradle of flowering plants boasting over 130 species of primitive angiosperms [5]. Moreover, India is recognized as one of the world's 12 Vavilovian Centers of Origin and diversification of cultivated plants, known as the Hindustan Center of Origin of Crop Plants [6]. At least 167 species of significant agri-horticultural crops and 320 species of their wild relatives, spanning 116 genera and 48 families have their roots here [7].

The country's agricultural wealth extends to its diverse landraces, such as the 50,000 to 60,000 varieties of rice, as well as other economically vital crops like wheat, sugarcane, legumes, sesame, eggplant, citrus, banana, mango, jute, ginger, turmeric, pepper, cinnamon and cardamom. This area is a haven for genetic diversity, critical for the resilience and productivity of these staple crops.

Moreover, India's extensive medicinal flora comprises around 3,000 angiosperm species with potential therapeutic qualities. Of these, approximately 1,300 species play a central role in traditional medicinal practices such as Ayurveda, siddha, unani and even modern allopathy. Additionally, the region is home to an array of primitive angiosperm genera, including *Alnus*, *Aspidocarya*, *Betula*, *Decaisnea*, *Euptelea*, *Exbucklandia*, *Haematocarpus*, *Holboellia*, *Houttuynia*, *Magnolia*, *Manglietia*, *Pycnarrhena* and *Tetracentron* [8].

Angiosperms, the most significant group of land plants, encompass over 300,000 species and represent 89.4% of embryophytes [9,10]. Their sudden emergence during the early Cretaceous and subsequent dominance in the later part of that era is considered one of Darwin's "abominable mysteries" [11]. The rapid rise and proliferation of this plant group transformed the planet's landscape and established the structural framework for most terrestrial ecosystems [10,12]. The diversification of angiosperms also facilitated the coevolution of various new organisms in the animal kingdom, including insects and contributed to the diversification of ferns [13,14].

Although there remain debates regarding the origin and lineage of this plant group, their emergence is generally accepted to have occurred in the early cretaceous [15-19].

Angiosperms have been identified across a multitude of geographic locations during the early cretaceous period, but their existence in India during this epoch remains uncertain [19,20]. Sahni reported a vesselless fossil wood designated homoxylon from the Rajmahal region, associating it with vesselless angiosperms [21]. However, Bose et al., reexamined the affinity of homoxylon sahni, situating it within *Bennettitales* and establishing a novel genus, *Sahnioxylon* [22].

In subsequent years, Sharma described Lesqueria Crane and Dilcher, while Banerji identified a fruiting body as sonajoricarpon and a flower-like structure from the Rajmahal formation [23,24]. Banerji drew parallels between sonajoricarpon and the fruits of the extant Fabaceous genus *Butea* Roxb [24]. Despite these early observations suggesting an angiosperm connection, further detailed scrutiny clarified that these fossils were not angiosperms but instead belonged to the gymnosperms [25].

According to Shankar, the Indian subcontinent is home to 34 species of Magnolia, including nine introduced species and hybrids [26]. This richness in biodiversity, both in terms of endemic plants and diverse crop varieties, positions India as a vital global repository of natural heritage, demanding rigorous conservation efforts to safeguard its ecological treasures.

India's political boundaries have shifted several times since the colonial era, affecting the classification and documentation of its rich biodiversity. Sarkar provided an early comprehensive account of endemic genera in India, listing 142 genera, of which four were also found in Bhutan and one extended into southern Tibet [27]. Subsequent reports varied in their listings of endemic genera, with Nayar reporting 147 genera, Ahmedullah reporting 140 and Mitra et al., reporting 121 [28-30]. These reports were based on the distribution information available at the time, but many genera initially considered endemic have since undergone taxonomic revisions with some being merged with parent or allied genera. According to Karthikeyan, there are 2,991 genera found in India, but a critical examination of literature and plant database websites reveals that only 49 genera are truly endemic to India [31]. These 49 genera belong to 22 families and include 80 taxa.

The endemic genera, 40 are confined to Peninsular India, four to the Himalayas and three to the Andaman and Nicobar Islands. The genus *Bentinckia* exhibits a disjunct distribution. *Hardwickia* is common throughout the dry deciduous forests of Peninsular and North India, except for the Northeast.

The families Poaceae, Apiaceae, Asteraceae and Orchidaceae account for approximately 51% of India's generic endemism, with Poaceae alone making up 27%. These genera encompass 34 herbaceous, 12 arborescent and three shrubby species. A total of 165 species (158 angiosperms, 5 gymnosperms and 1 pteridophyte) belonging to 142 genera and 57 families are recorded from the campus of Sangat Sahib Bhai Pheru Khalsa Senior Secondary School Faridkot, Punjab, India from July 2022 to April 2023. Out of 57 families, grass family Poaceae is dominant with represented with 15 species. Ninety-five documented as a weed species, 67 species are cultivated and 3 species both cultivated as well as wild species. Eighty-five species are annual and 80 are perennials.

An initial study in the Subansiri region of the eastern Himalayas uncovered substantial levels of plant endemism. As part of a comprehensive effort to sample different forest types and map biologically rich areas, the study assessed the observed species to determine their endemic status within this significant global biodiversity hotspot. The research included documenting the count of individuals, species, genera and families across both natural and semi-natural forest types. The investigation involved random sampling of 122 plots in different forest types and cataloged 764 plant species, with 59 of them found to be unique to the region. The overall species endemism rate was calculated at 13 per hectare. These 59 endemic species were distributed across 27 families and 46 genera. Interestingly, half of the endemic species were concentrated in just five families: Rubiaceae, Lauraceae, Acanthaceae, *Magnoliac*eae and Rosaceae. Analysis of the stem size class distribution of the most abundant endemic tree species across three primary forest types offered insight into their quantitative status. The study adopted a proportional stratified random sampling method across various vegetation types and utilized satellite remote sensing data to map the region. The discovery of numerous primitive genera and families pointed to a long evolutionary history, underscoring the region's deep-seated botanical heritage and notable species endemism [32].

Rawat et al., conducted a study in the Kandi region of Hoshiarpur, India, documenting an extraordinary collection of 176 plant species spanning 57 distinct families and 133 genera [33]. This remarkable breadth underscores the region's exceptional botanical diversity. Among the species, 175 were angiosperms and one was a gymnosperm, reflecting the overwhelming dominance of flowering plants in the area. Within the angiosperms, dicotyledons constituted a striking 78.3% (137 species across 105 genera), while monocotyledons represented 21.7% (38 species across 27 genera).

DISCUSSION

The study showcased Poaceae as the most prominent family, comprising 30 species across 21 genera. Other significant families included Papilionaceae, Caesalpiniaceae, Euphorbeaceae, Apocynaceae, Acanthaceae and Mimosaceae. Trees emerged as the dominant life form, accounting for 36.9% of the species, followed by shrubs (22.7%), grasses (17.1%), herbs (13.6%), climbers (8.5%) and sedges (1.1%).

The investigation identified 33 plant species from 21 families employed by the local populations of Satrod Khurd and Dabra villages for treating a range of gastrointestinal disorders, including diarrhea and indigestion, as well as skin afflictions. The Fabaceae family emerged as the most prominent, contributing four species, while Lamiaceae followed closely with three species. Other families such as Amaranthaceae, Rutaceae, Meliaceae, Asclepiadaceae, Myrtaceae, Euphorbiaceae and Moraceae each offered two species.

Notable botanical families like Crassulaceae, Cannabaceae, Boraginaceae, Solanaceae, Menispermaceae, Rhamnaceae, Poaceae, Papaveraceae and Combretaceae each provided one species. Important plant components such as leaves, seeds, fruits, bark, roots, twigs and flowers were utilized to treat conditions like diarrhea, dysentery, blood purification and various skin disorders. Several versatile plants, including *Calotropis procera*, *Argemone mexicana*, *Datura metel* and *Azadirachta indica*, exhibited therapeutic efficacy across multiple ailments. The collected data was carefully compared with established literature, peer-reviewed research papers and reputable online sources to ensure its validity and reliability. This comprehensive approach underscored the extreme ethnobotanical knowledge and practices inherent to the region [34].

This comprehensive analysis of the region's forest flora reveals invaluable insights into its rich species diversity, the prominence of particular plant families and the varied composition of life forms. The study highlights the ecological richness and significance of the Kandi region, emphasizing its importance as a center of biodiversity.

In a comprehensive 2023 study conducted by Singh et al., an intriguing assortment of twenty-five angiosperm wild species was identified across 23 genera and 14 families as weeds in crops, gardens and waste areas in Faridkot, Punjab, India [4]. The Asteraceae family emerged as the most prominent, with five distinct species, followed by Poaceae and Solanaceae, each showcasing three species. Brassicaceae, Malvaceae and Scrophulariaceae each presented two species, while the remaining families each held a single species. Of the 23 genera, only two *Solanum* and *Veronica* featured two species apiece, while the rest were monotypic, emphasizing the diverse botanical landscape. Among the 25 species identified, 22 were dicots, highlighting their dominance, while the remaining three were monocots. This study sheds light on the remarkable biodiversity of the region and its dynamic exchange with agricultural and natural ecosystems.

Kaur et al., documented an extraordinary collection of 294 plant species, surround 288 angiosperms, 3 gymnosperms and 3 pteridophytes, across 232 genera and 79 families from Bassi Umar Khan and Atwarapur in the Bhunga block of district Hoshiarpur, Punjab [35]. The Fabaceae family was most prevalent, trailed by notable families such as Poaceae, Asteraceae, Cucurbitaceae and Solanaceae. Of the 294 species, 142 were herbaceous, 66 were trees, 52 were shrubs and 34 were climbers. Among these, 78 species were traditionally utilized in medicinal formulations, representing 26.5% of the overall flora in the study area. Herbs dominated traditional use in various medicinal preparations, followed by trees, shrubs and climbers. The study highlighted that 25 plants were frequently used to treat gastrointestinal disorders, while 16 species were found effective in controlling diabetes. This analysis underscores the region's rich floristic diversity and the extreme traditional knowledge held within the study area.

An extensive study of angiosperm diversity in the Doaba region of Punjab, India, revealed a remarkable total of 464 species across 337 genera and 99 families. Among these species, 88% were dicots, while the remaining 12% were monocots. The data included wild, cultivated and ornamental species. Fabaceae was the most dominant family with 60 species, followed by Asteraceae (33 species), Poaceae (29 species), Euphorbiaceae (20 species), Amaranthaceae (18 species) and Cucurbitaceae and Solanaceae (17 species each).

Out of the total species recorded, 255 were herbs, 65 were shrubs, 85 were trees and 59 were climbers. Additionally, the study identified six species new to the flora of Punjab. This investigation emphasizes the Doaba region's rich angiosperm diversity and underscores the urgent need for its documentation and conservation [36].

The emergence of angiosperms on Earth took place during the Jurassic period. The oldest known angiosperm, *Florigerminis jurassica* Cui et al., (also known as the 'Jurassic flower bud'), dates back approximately 164 million years to the Jurassic period and was unearthed in Inner Mongolia, China, in 2022 [37].

During the early Cretaceous, angiosperms were limited to regions situated between latitudes 45° N and 45° S. These flowering plants gradually began to supplant the non-flowering vegetation of the Jurassic era, establishing a firm presence in the northern hemisphere only in the late Cretaceous period.

Hallier theorized that this plant group originated on a continent located in the southern Pacific Ocean; however, no such continent has ever been found [38]. Nonetheless, researchers like Bailey, Axelrod and Thorne all concurred that the cradle of angiosperms was located in the southern or western Pacific region [39-41]. This extensive area spans from Assam in the west to Australia and the Fiji Islands in the east, surround regions such as Myanmar, southern China, Japan, Malaysia, New Zealand and New Caledonia. While fossil evidence does not specify the precise origin, it does confirm that angiosperms arose within the tropical belt before gradually expanding to higher latitudes.

Within this broad area, known as the Southwest Pacific Basin, primitive angiosperms thrive in abundance. Many early families are isolated to this region and primitive representatives of other families can also be found here.

The paleobotanical record of seed plants remains incomplete. Plants with affinities to ranalian and amentiferous species rank among the oldest of paleobotanical finds. Seed-bearing pteridosperms, possessing fern-like foliage, appear to provide the most plausible evolutionary link to flowering plants, including the seed pod and the cupule that encloses the seed.

According to Cronquist, the subclass Magnoliidae encompasses the most ancient and primitive angiosperms still in existence today [42]. This subclass comprises several time-honored plant families, such as water lilies (Nymphaeaceae), buttercups (Ranunculaceae) and *magnolias* (Magnoliaceae). The Magnoliaceae family showcases distinct primitive traits, including: Large, striking flowers adorned with numerous tepals; abundant spirally arranged free stamens at the base of a cone-like receptacle, which bears numerous spirally arranged free carpels.

As the plant matures, the carpel-bearing section transforms into a woody, cone-like aggregate composed of seed-bearing follicles. Each seed is ensconced within a fleshy, red outer layer known as an aril and is connected to its follicle by a slender, thread-like funiculus.

Additional primitive floral attributes comprise actinomorphic (radially symmetrical) flowers that are perfect (both male and female reproductive structures) and complete (possessing all four floral organs) along with an elongated floral axis or receptacle. These characteristics are prominently displayed in both the flowers and fruits of the Magnolia species, serving as a testament to the ancient lineage of this family.

The Angiosperm Phylogeny Group IV (APG IV) system of classification recognizes the clade Magnoliids as a collection of ancient angiosperms, consisting of four orders: *Canellales*, Laurales, *Magnoliales* and *Piperales*. The *Canellales* order, with families Canellaceae and Winteraceae, is absent in India. However, India hosts a notable presence of other orders: The Laurales order, represented by Hernandiaceae and Lauraceae families; the *Magnoliales* order, surround Myristicaceae, Magnoliaceae and Annonaceae families and the *Piperales* order, which includes the Saururaceae, Piperaceae and Aristolochiaceae families.

CONCLUSION

A key component of India's ecological richness is the diversity of its angiosperms, which are a reflection of the vast range of habitats and climatic conditions found throughout the nation. The critical need to preserve this botanical variety is emphasized in this review, since it is essential to the health of ecosystems and the advancement of fields like environmental science, pharmacology and agriculture. However, there are significant risks to this biodiversity due to the increasing degradation of ecosystems, as well as the consequences of climate change and human activity.

In order to address these issues, a thorough strategy is needed. This entails using cutting-edge genetics, conservation biology and ecosystem management studies, as well as implementing strict conservation laws. Furthermore, educating the local population and implementing sustainable livelihood initiatives might be important in ensuring the protection of these species.

India's angiosperms have enormous potential for upcoming scientific discoveries and advancements. It is imperative that this biodiversity be preserved and used responsibly on a worldwide scale. We can guarantee the preservation of this priceless natural resource for the benefit of both the current and future generations by encouraging cooperation between scientific domains and policy efforts.

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RESEARCH ARTICLE

Analyzing the impact of growth hormones on *in vitro* propagation of *Anacyclus pyrethrum*

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Modi G, Soni RK. Analyzing the impact of growth hormones on *in vitro* propagation of *Anacyclus pyrethrum*. AGBIR.2024;40(4):1226-1228.

Traditional medicine makes use of the wild species *Anacyclus pyrethrum*, also known as *A. pyrethrum*, which belongs to the *Asteraceae* family. In order to commence the cultivation of *Anacyclus pyrethrum*, the study employed 4 to 5 cm immature nodal shoot segments. Antioxidant therapy solved the early issues of leaching and browning when the axillary meristem was activated on MS media with 2.0 mg/L of 6-Benzylaminopurine (BAP), resulting in profuse shoot growth. 0.5 mg/L 6-benzylaminopurine and kinetin amplified cultures were subculturing on Murashige and Skoog (MS) medium. Root induction was achieved on half-strength MS medium with 2.0 mg/L Indole-3-Butyric Acid (IBA) and 0.2% activated charcoal and *ex vitro* rooting with pulse administration of 200.0 mg/L indole-3-butyric acid demonstrated efficacy. The tissue culture approach shown to be reliable and appropriate for large-scale greenhouse cultivation of akarkara plants.

Key Words: *Anacyclus pyrethrum*; *Micropropogation*; *Growth hormone*; *Auxin*

INTRODUCTION

Akarkara is an herbaceous plant from the Compositae (*Asteraceae*) family, is also known as the toothache plant, Brazil cress or para cress. Its unique ability to numb the tongue when its flower buds are consumed has earned it the nickname "toothache plant". Beyond its culinary uses, akarkara is renowned in traditional medicine for its stimulant and diaphoretic properties. The root contains pyrethrin, which is used therapeutically to treat conditions like rheumatism, neuralgia and toothaches. This hardy plant, characterized by its daisy-like flowers and lobed leaves, thrives in arid conditions when grown in well-drained, sandy soil. Although its conservation status is of least concern, sustainable harvesting remains significant.

Akarkara's essential oil and alkaloids, especially spilanthol are known for their virilizing, nervine, heart tonic and antimicrobial properties. Recognized in ayurveda for its diverse medicinal benefits, akarkara is considered an aphrodisiac and a tonic for the male reproductive system. A technique for micropropagation of *Anacyclus pyrethrum* was developed by Singh et al., showing the best response from cotyledonary nodal explants on MS medium with 2.5 µM Kn, yielding an average of 8.88 ± 0.28 shoots per explant [1]. During sub-culturing, the regenerated shoots proliferated and for root induction, elongated shoots exposed to 5 or 10 µM Indole-3-Acetic Acid (IAA) or 5 µM Naphthaleneacetic Acid (NAA) were most successful.

MATERIALS AND METHODS

The study by Singh et al., investigated callogenesis and pellitorine accumulation in *Anacyclus pyrethrum* a medicinal herb [2]. Using cotyledon, hypocotyl and root explants on MS media supplemented with 2,4-Dichlorophenoxyacetic acid (2,4-D), they found that lower 2,4-D concentrations favored root and hypocotyl callus formation, while higher concentrations favored cotyledon callus formation. The weight of harvested calli increased linearly over time. Between days 30 and 75, there was a significant increase in pellitorine accumulation, with the highest amount (94.50 µg/g dry weight) observed in cotyledon calli on day 75. The antioxidant activity of the pellitorine produced from *A. pyrethrum* callus was assessed using the 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) method and an efficient procedure for large-scale production was established [3,4].

Nodal shoot segments of *Anacyclus pyrethrum*, sourced from greenhouse or nursery plants, were used as explants for culture initiation. After surface sterilization with bavistin, antibiotics and $HgCl_2$, the explants were treated with a chilled antioxidant solution. Various concentrations of kinetin or BAP were applied on MS media to promote the production of multiple shoots and the multiplication of axillary buds [5]. Culture multiplication required repetitive transfer and subculturing on media supplemented with ascorbic acid and activated charcoal. Different concentrations of BAP were tested on Murashige and Skoog (MS), Modified Murashige and Skoog (MMS), Woody Plant (WP) and white's media, either alone or in combination with kinetin, IAA or NAA for shoot multiplication [6,7].

In vitro, regenerated shoots were rooted in half-strength MS medium supplemented with various amounts of IBA or NAA and activated charcoal. One method of *ex vitro* rooting involved pulse-treating with IBA, NAA. Subsequently, the plants were transferred to soilrite in bottles for root induction and greenhouse hardening. Once hardened, the plantlets were placed in polybags containing a mixture of vermicompost, black soil and sandy soil [8].

Sections of juvenile nodal shoots, measuring 4 to 5 cm in length, were found suitable for culture initiation. However, explant leaching and browning posed significant challenges to bud break and culture establishment. To mitigate this, the nodal explants were treated with an antioxidant solution for 20 min. On MS medium supplemented with 2.0 mg/L of BAP, 90% of the explants showed bud break and produced 2-3 shoots per node. Conversely, on MS medium with 1.0 mg/L of BAP, the explant's response and shoot development were poor [9]. Higher concentrations (3.0 mg/L) of BAP resulted in bud breaking from the axillary meristem and callus formation at the base. Kinetin treatments also induced bud proliferation, but the growth and number of shoots per explant were considerably lower (Table 1).

TABLE 1

Impact of BAP and kinetin concentrations on bud break and multiple shoot induction from *Anacyclus pyrethrum* nodal explants on MS+additives

Concentration of cytokine (mg/L)	Response (%)	Shoot no. ± SD	Shoot length (cm) ± SD
BAP			
0.5	45	1.35 ± 0.5	0.95 ± 0.28
1	66	1.4 ± 0.55	1.08 ± 0.3
2	95	1.8 ± 0.5	1.2 ± 0.19
3	45	1.5 ± 0.3	1.3 ± 0.25
Kinetin			
0.5	-	-	-

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1	25	0.75 ± 0.51	0.47 ± 0.15
2	55	1.4 ± 0.55	1.2 ± 0.2
3	25	1.2 ± 0.59	1.33 ± 0.18

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; SD: Standard Deviation.

RESULTS AND DISCUSSION

Multiplication and maintenance of cultures

Repeated transfers of the mother plant for two to three cycles resulted in the amplification of *Anacyclus pyrethrum* shoots (Table 2). Shoot multiplication was achieved on MS medium supplemented with 0.5 mg/L of both kinetin and BAP, along with 100 mg/L ascorbic acid and 0.1% activated charcoal. The inclusion of activated charcoal was significant for proper culture growth, as it mitigated the phenol leaching at the culture bases, which otherwise slowed the multiplication rate [10,11]. Approximately 12-13 shoots were regenerated on the shoot multiplication medium with sub culturing every 20 to 25 days (Table 3).

TABLE 2

Production of shoots with repeated transfers of the *Anacyclus pyrethrum* mother explant on MS+0.5 mg/L BAP+additives

Passages	Shoot no. ± SD	Shoot length (cm) ± SD
I	2.6 ± 0.4	1.95 ± 0.4
II	6.9 ± 1.2	3.1 ± 0.3
III	9.1 ± 0.7	2.7 ± 0.3
IV	5.1 ± 0.8	2.1 ± 0.2

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; SD: Standard Deviation.

TABLE 3

Impact of different growth regulator combinations and doses on *Anacyclus pyrethrum* shoot multiplication on MS+additives

Concentration of cytokine (mg/L)	Shoot no. ± SD	Shoots length (cm) ± SD
BAP		
1	3.91 ± 0.91	2.63 ± 0.77
0.5	4.8 ± 1.25	3.31 ± 0.89
0.25	3.31 ± 0.95	1.89 ± 0.47
BAP 0.5+kinetin		
1	7.81 ± 0.69	3.22 ± 0.45
0.5	12.72 ± 0.91	3.91 ± 0.37
0.25	9.86 ± 0.71	1.35 ± 0.37
BAP 0.5+NAA		
1	6.43 ± 0.38	1.6 ± 0.98
0.5	6.71 ± 0.23	1.3 ± 0.65
0.25	7.91 ± 0.75	0.81 ± 0.28
BAP 0.5+IAA		
1	5.89 ± 0.91	1.31 ± 0.47
0.5	7.89 ± 0.79	1.33 ± 0.77
0.25	5.45 ± 0.67	1.29 ± 0.29

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; SD: Standard Deviation; NAA: Naphthaleneacetic Acid; IAA: Indole-3-Acetic Acid.

Using BAP alone at various concentrations on MS medium resulted in the differentiation of only 3-5 shoots. Compared to kinetin, combining NAA or IAA with 0.5 mg/L of BAP was less effective, yielding fewer and shorter shoots. Of all the media types tested, MS medium proved to be the most suitable for culture proliferation. Cultures on MMS medium began to yellow, while those on WP and white's media showed very low rates of shoot growth and multiplication (Table 4).

TABLE 4

Effects of different culture media types on *Anacyclus pyrethrum* shoot multiplication (each medium treated with 0.5 mg/L of BAP and kinetin)

Type of media	Shoot no. ± SD	Shoot length (cm) ± SD
MS	12.7 + 0.86	3.45 + 0.17
MMS	9.71 ± 0.97	2.98 ± 0.18

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; MMS: Modified Murashige and Skoog; SD: Standard Deviation.

After three to four cycles of maintaining shoot cultures on fresh media, tuber development occurred at the nodes of regenerated shoots. Initially, the nodes formed green, tumor-like structures that eventually turned brown and exhibited root differentiation with abundant root hair development. These tubers later produced shoots with well-developed roots [12-14].

Rooting of *in vitro* produced shoots

Shoots planted on half strength MS medium supplemented with 2.0 mg/L of IBA and 0.2% of activated charcoal were successfully produced *in vitro*. As shown in Table 5, a rooting percentage of 90%-95% was achieved. In contrast, NAA was found to be less effective at inducing roots from *Anacyclus pyrethrum* shoots.

TABLE 5

Impact of auxins (IBA and NAA) on root induction from *Anacyclus pyrethrum* shoots that have been *in vitro* regenerated on half strength MS medium

Concentration in (mg/L)	Response (%)	Root no. ± SD	Root length (cm) ± SD
IBA			
1	81	1.9 ± 0.55	0.9 ± 0.60
1.5	87	2.9 ± 0.45	1.2 ± 0.15
2	93	3.3 ± 0.92	2.7 ± 0.2
3	73	1.9 ± 0.77	1.2 ± 0.2
NAA			
1	61	1.5 ± 0.58	0.96 ± 0.9
1.5	66	1.8 ± 0.77	0.97 ± 0.11
2	73	2.7 ± 0.58	1.7 ± 0.12
5	55	1.9 ± 0.49	0.77 ± 0.71

Note: MS: Murashige and Skoog, SD: Standard Deviation; NAA: Naphthaleneacetic Acid; IBA: Indole-3-Butyric Acid.

Ex vitro rooting of shoots

By pulsing 200 mg/L of IBA over the course of three minutes, shoots grown *in vitro* became rooted. Three to four roots were formed from each of the 90%-95% of the pulse-treated shoots that rooted (Table 6). Moreover, NAA worked well for roots at all concentrations.

TABLE 6

Impact of pulse treatments with IBA or NAA concentrations on the *ex vitro* rooting of *Anacyclus pyrethrum* regenerated shoots

Concentration of auxin	Response (%)	Root no. ± SD	Root length in (cm) ± SD
IBA			
100	65	1.9 ± 0.65	2.5 ± 0.17
200	95	3.1 ± 0.99	3.5 ± 0.14
500	75	1.9 ± 0.49	2.9 ± 0.15
NAA			
100	75	1.6 ± 0.59	1.9 ± 0.15
200	81	2.7 ± 0.69	2.5 ± 0.22
500	62	2.9 ± 0.79	1.5 ± 0.31

Note: SD: Standard Deviation; NAA: Naphthaleneacetic Acid; IBA: Indole-3-Butyric Acid.

Observation

Juvenile nodal shoot segments of *Anacyclus pyrethrum* were effectively used to initiate cultures, leading to the development of multiple shoots through axillary meristem activation on MS medium supplemented with 2.0 mg/L BAP. More than 90% of the nodal explants produced 2-3 shoots [15,16]. Initial issues with leaching and browning were mitigated using antioxidant treatments. Compounds such as ascorbic acid and sodium hydrosulphite were successful in preventing darkening. Other effective agents include cystine, Diethyldithiocarbonate (DTT), sodium bisulphate, citric acid and polyclar [17]. In the plant biotechnology laboratory in Jodhpur, ascorbic acid and citric acid have been utilized to prevent browning and deterioration in cultures of various plant species, including woody plants and trees. Abdelwahd et al., used oxidants and absorbents to reduce the impact of leached phenolics on faba bean regeneration *in vitro* [18].

For *Anacyclus pyrethrum*, nodal explants were cultured and subsequently multiplied through subculturing on MS medium with activated charcoal as an adsorbent and ascorbic acid as an antioxidant. The optimal BAP concentration for shoot multiplication was found to be 0.5 mg/L. Once the axillary meristems are activated, the medium is conditioned for shoot growth, requiring lower levels of cytokinin. This study demonstrated a high rate of shoot multiplication (12-13 shoots per inoculum) for akarkara cultivation.

Root production in adventitious shoots can be influenced by various factors [19]. Heimsch et al., reviewed the organization of the root apical meristem in angiosperms [20]. Micropropagated shoots of *Anacyclus pyrethrum* can be rooted on half-strength MS medium supplemented with 2.0 mg/L IBA and 0.2% activated charcoal. Additionally, a pulse treatment with 200.0 mg/L IBA effectively stimulated rooting *in vitro*. More than 90%-95% of the shoots underwent successful rooting both *in vitro* and *ex vitro*. IBA was identified as the most effective auxin for root induction in akarkara. The micropropagated plants were then acclimated and hardened in a greenhouse. This tissue culture method is proven to be repeatable and suitable for large-scale plant production.

CONCLUSION

Recently sprouted shoots were utilized as explants, with nodal shoot segments proving effective for culture initiation. Multiple shoots were generated by activating the axillary meristem on MS medium supplemented with 2.0 mg/L BAP. Initial issues with browning and leaching were managed through antioxidant treatment. The cultures were subsequently proliferated by subculturing on MS medium enhanced with ascorbic acid and activated charcoal. For optimal shoot multiplication, a lower concentration of BAP (0.5 mg/L) was found to be ideal. Rooting was successfully induced on half-strength MS medium containing 2.0 mg/L IBA and 0.2% activated charcoal. A pulse treatment with 200.0 mg/L IBA resulted in over 90%-95% of the shoots developing roots both *in vitro* and *ex vitro*. The micropropagated akarkara plants were effectively hardened and acclimated in a greenhouse.

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REVIEW ARTICLE

Effect of heat stress on wheat production in semi-arid region of Rajasthan

Ravi Kumar*, Sunita Bhandari, Sarita, Gayathri PM

Kumar R, Bhandari S, Sarita, et al. Effect of heat stress on wheat production in semi-arid region of Rajasthan. AGBIR.2024;40(4):1210-1213.

Producing sufficient food to meet the demands of India's growing population, projected to reach 10 billion by 2050, presents significant challenges due to declining arable land, water scarcity and unpredictable weather patterns magnified by climate change. Wheat (*Triticum aestivum* L.), a staple crop providing 20% of global caloric and protein intake, faces severe threats from heat stress, which has already reduced global productivity by approximately 5% since the 1980s. This review examines the impact of heat stress on wheat production, focusing on physiological, biochemical and yield-related aspects, with a particular emphasis on the semi-arid region of Rajasthan, India. High temperatures during significant growth stages disrupt photosynthesis, reduce enzymatic activities and alter starch accumulation in grains, ultimately decreasing yield and grain quality. Additionally, heat stress induces oxidative damage through the accumulation of Reactive Oxygen Species (ROS), impacting membrane stability and protein expression. The synthesis of Heat Shock Proteins (HSPs) plays a vital role in mitigating heat-induced damage, although their efficacy is often overwhelmed under extreme stress. This review underscores the necessity of developing heat-tolerant wheat cultivars to sustain productivity in the face of rising temperatures and highlights the complex exchange between temperature stress and wheat physiology.

Key Words: *Heat stress; Photosynthetic efficiency; Anthesis; Reactive oxygen species; Heat shock proteins*

INTRODUCTION

The most significant task of the century is to produce sufficient food to feed India's increasing population, while also coping with decreasing amounts and quality of arable land, reducing water supplies and increasingly unpredictable weather due to climate change [1]. According to Food and Agriculture Organization (FAO) estimates, in order to meet future demand, the world will need an extra 198 million tons of wheat by 2050, meaning that developing nations' wheat production will need to rise by 77% [2]. About 30% of the world's cereal acreage is devoted to the primary, stable crop of wheat, which feeds 36% of the world's population. About 20% of the calories and proteins in a human diet come from wheat. Heat stress is estimated to have decreased global wheat productivity by as much as 5% since the 1980s [3,4]. Based on the severity of the high temperature, drought, salinity, waterlogging and mineral toxicity stresses, such an increase in world's temperature may have a major impact on productivity. High temperature-induced heat stress is defined as an increase in air temperature that lasts longer than a certain threshold and is strong enough to harm or permanently damage agricultural plants in general [5]. The issue of heat stress is made worse when soil temperature rises due to an increase in air temperature and a decrease in soil moisture. As a result, heat stress has emerged as a serious threat to worldwide crop productivity [6-9]. Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world, providing essential nutrients to a large part of the global population. In Rajasthan, wheat occupies a significant portion of the cultivated land, contributing substantially to the state's economy and food security. However, the semi-arid climate of Rajasthan, characterized by high temperatures and low rainfall, increases the challenges of wheat production. Heat stress in particular is a significant factor that affects the growth, development and yield of wheat. The climate in Rajasthan is predominantly dry and hot, with temperatures often exceeding 40°C during the wheat growing season. The region receives an annual rainfall of approximately 250-500 mm, which is sporadic and unpredictable. These climatic conditions create a challenging environment for wheat cultivation, making the crop highly susceptible to heat stress. Heat stress affects wheat at various developmental stages, leading to a range of physiological responses. High temperatures during the germination phase can lead to reduced germination rates and poor seedling vigor. Heat stress affects the enzymatic activities essential for seed germination, resulting in delayed or uneven crop establishment. Wheat production in India had observed a quantum jump from 6.5 million tons in 1950 to 112 million tons in 2023. A 33% yield loss in late-sown wheat varieties was noted as a result of high temperatures, suggesting the necessity to produce heat-tolerant wheat cultivars in order to achieve sustainable production. The climate agency said that "the global average temperature for the past 12 months (April 2023-March 2024) is the highest recorded at 0.70°C above the 1991-2020 average and 1.58°C above the 1850-1900 pre-industrial average. The 60%-70% starch content of wheat grains steadily decreases at high temperatures. Because granule-bound starch, soluble starch and sucrose synthase are inactive during the grain filling phase, high temperatures prevent starch from building up in grains. Additionally, it reduces the synthesis of starch, translocates carbohydrates from stem reserves and modifies the structure of the seed's endosperm and aleurone layer, all of which have an impact on the growth of grains [10-13].

LITERATURE REVIEW

Physiological impact

Since photosynthesis is the physiological activity most susceptible to temperature changes, any decrease in photosynthesis has an impact on wheat growth and grain yield [14-16]. Heat stress impairs the photosynthetic efficiency of wheat plants by affecting chlorophyll content and disrupting the functioning of photosystem II [17]. The heat-induced increase in thylakoid membrane fluidity and Photosystem II's (PSII's) electron-transport dependent integrity are the main causes of PSII's vulnerability to high temperatures [18]. A notable rise in the baseline level of chlorophyll fluorescence, which is indicative of photosynthetic inhibition, is frequently used to suggest the inhibition of PSII electron transport during heat stress [19]. We must know how crops respond to elevated temperatures and how tolerance to heat can be improved in order to adapt new crop varieties to the future climate [20]. The best temperature for wheat anthesis and grain filling is between 12°C and 22°C. Exposure to temperatures higher than this can drastically reduce grain yield [21-23]. Heat stress affects grain growth because temperature variations directly affect assimilate translocation and the length and pace of grain filling. The degree of heat stress determines how much harm is caused by heat. Increased respiration rates under high temperatures lead to a depletion of carbohydrates, which adversely affects plant growth and development [24]. Wheat plants under heat stress exhibit reduced water uptake and increased transpiration rates, leading to a negative water balance [25]. Stomatal closure, a common response to heat stress, further reduces CO_2 assimilation, impacting photosynthesis and overall plant productivity (Table 1) [26].

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TABLE 1
Optimal temperature requirements of wheat at different growth stages

Stages	Optimum temperature (°C)	Minimum temperature (°C)	Maximum temperature (°C)
Root growth	17.2 ± 0.87	3.5 ± 0.73	24 ± 1.21
Shoot growth	18.5 ± 1.90	4.5 ± 0.76	20.1 ± 0.64
Leaf initiation	20.5 ± 1.25	1.5 ± 0.52	23.5 ± 0.95
Terminal spikelet	16 ± 2.3	2.5 ± 0.49	20 ± 1.6
Anthesis	23 ± 1.75	10 ± 1.12	26 ± 1.01
Grain filling duration	26 ± 1.53	13 ± 1.45	30 ± 2.13

Biochemical impact

Heat stress triggers several biochemical changes in wheat plants, including the accumulation of Reactive Oxygen Species (ROS), alterations in membrane stability and changes in protein expression. The overproduction of ROS under heat stress causes oxidative damage to cellular structures, including lipids, proteins and nucleic acids. Wheat plants activate antioxidant defense mechanisms to mitigate this damage, but the efficiency of these systems can be overwhelmed under severe stress conditions. Superoxide radicals, hydroxyl radicals and hydrogen peroxide are examples of ROS that are naturally formed in cells, but excessive amounts of these substances can be hazardous [27]. ROS are produced and accumulate as a result of heat stress [27-30]. Thus, antioxidant systems' detoxification of plants is significant for shielding them from heat stress [31,32]. Plants have both enzymatic and non-enzymatic antioxidant mechanisms as part of their antioxidant defense system. Ascorbate peroxidase, dehydroascorbate reductase, glutathione S-transferase, superoxide dismutase, catalase, guaiacol peroxidase and glutathione reductase are the components of the enzymatic antioxidant system [33]. Tocopherols, ascorbate and glutathione are examples of non-enzymatic antioxidants. High temperatures disrupt the lipid composition of cell membranes, leading to increased permeability and leakage of cellular contents. Membrane stability is a significant factor determining the extent of heat stress tolerance in wheat. Wheat plants produce Heat Shock Proteins (HSPs) in response to elevated temperatures. These proteins play a significant role in protecting cellular components from heat-induced damage and maintaining protein homeostasis. The chemical reaction to heat stress that has been investigated the most is the expression of HSPs. HSPs prevent heat-induced protein aggregation, which allows proteins to refold during the recovery phase [34-37]. According to Coles et al., the two most important factors influencing wheat grain quality are grain size and protein concentration [38]. Heat stress during the grain-filling phase reduces the amount of starch deposited in the grain, which increases protein concentration by permitting more nitrogen per unit of starch [39]. These findings have been reported by Wardlaw et al., and Gooding et al., [40 41]. A basic reaction to heat stress is the expression of HSP genes [42]. Wheat experiences a decrease in normal protein synthesis when exposed to high temperatures (>35°C), although HSPs are still generated [43].

Yield-related impact

Heat stress during significant growth stages such as anthesis and grain filling can lead to significant yield reductions. Heat stress can reduce the number of grains per spike and the individual grain weight, resulting in lower overall yield. High temperatures during the grain filling period accelerate the senescence process, limiting the duration of grain filling and reducing final grain size. Increased temperature affects both grain weight and number [44]. The developmental stage at which the elevated temperature occurs determines how temperature affects each of these grain yield components. For example, temperatures exceeding 20°C between spike initiation and anthesis may significantly limit the quantity of grains per spike [45]. Heat stress speeds up development of the spike reducing spikelet number and thus, the number of grains per spike [46]. The time between the onset of the spike and anthesis is not the most vulnerable to heat stress, though. The window of time between the emergence of double ridges on the flag leaf and shoot apex is the most important. During this time, an inverse relationship has been discovered between the number of grains per spike and the duration of heat stress [47]. This sensitivity is caused by spikelets that start to emerge in the spike-known as the double ridge stage-from tissue ridges between ridges of undifferentiated leaf primordia. Then, floret production begins on each spikelet meristem. Both the number of spikelets per spike and the number of grains per spikelet decrease with a reduction in the time between emergence and double ridge and anthesis [48]. The quality of wheat grain, including protein content and gluten strength, is also compromised under heat stress. For protein composition, high temperature stress reduces the glutenin/gliadin ratio and limits the synthesis of the larger Sodium Dodecyl Sulfate (SDS)-insoluble glutenin polymers which causes wheat dough to have weaker viscoelasticity properties [49].

DISCUSSION

According to McClung et al., heat stress interferes with a number of plant functions, causing morpho-physiological changes in wheat plants that impede their growth and ultimately result in a significant loss of production [50]. The way that plants react to heat stress varies greatly depending on the temperature, its length and the stage of growth that is being affected. Depending on the crop species, photosynthetic activities may withstand heat stress more readily and are rather stable between 30°C and 35°C. However, when temperatures rise above 40°C, photosynthesis is negatively impacted. Elevated temperatures cause O_2 and CO_2 to become less soluble; conversely, a higher concentration of CO_2 than O_2 leads to greater photorespiration and reduced photosynthesis [51]. Activities at Ribulose Bisphosphate Carboxylase Oxygenase (RUBISCO) break down in hot weather [52]. Reduced photosynthetic capacity under heat stress [53]. A significant part of leaf photosynthesis is played by photosystem II, one of the photosynthetic apparatus's components that is comparatively more resistant to heat stress than drought [54]. Furthermore, it is thought that mitochondrial respiration plays a significant role in determining a plant's ability to develop and survive [55]. Wheat morphology and seed germination are adversely affected by heat stress [56]. The symptoms of heat stress include decreased root diameter, length and quantity of roots. Because there is less carbon partitioning to the roots under heat stress during reproductive development, root growth is similarly slowed down [57]. The ideal temperature range for root growth is extremely limited when compared to other growth processes [58].

Heat stress causes fewer grains to form, which lowers the wheat harvest index [59]. The impact of heat stress on grain size and quantity however, differs depending on the developmental phases that are affected. For example, temperatures over 20°C during the period between spike initiation and anthesis accelerate spike development but decrease the amount of grains and spikelets per spike [60]. Male sterility results from heat stress's detrimental effects on pollen cells and microspores [61]. Depending on the genotype, wheat can become completely sterile even at temperatures exceeding 30°C during floret development [62]. According to Hedhly et al., wheat anther generated under three days of heat stress during anthesis was discovered to be physically aberrant and non-functional florets [63]. A daytime high temperature of 31°C/20°C may also result in grain shrinkage because of modifications to the endosperm and aleurone layer's structural makeup [64].

High temperatures have a significant impact on the wheat grain filling stage. According to Dias et al., heat stress typically shortens the grain filling time and speeds up the rate of grain filling [64]. However, in plants with varying grain weight stability, the rate and length of grain growth reduced [65]. Grain filling time in wheat can be shortened by 12 days for every 5°C increase in temperature above 20°C [66]. Compared to daytime temperature, an increase in night time temperature is more sensitive, shortens the grain filling period and lowers the grain yield. A reduction of 3 to 7 days was seen in the grain filling period by night time temperatures of 20°C to 23°C [67]. The rate of grain filling in wheat cultivars under day/night temperatures of 32°C/22°C was found to be significantly lower recently than at 25°C/15°C. Many cereals and legumes are affected by heat stress in terms of grain quality, primarily

due to reduced nutrient remobilization and assimilation [68]. According to Lizana et al., heat stress has no effect on the protein concentration of wheat grain; nevertheless, Iqbal et al., found a significant link between leaf nitrogen content and grain protein [69,70].

CONCLUSION

Heat stress poses a significant challenge to wheat production in the semi-arid region of Rajasthan. Understanding the physiological responses, biochemical responses and yield related responses of wheat to heat stress is essential for developing effective mitigation strategies. The frequency of high temperatures that stress wheat is predicted to rise globally. Grain setting, length and rate are all significantly impacted by heat stress, which eventually lowers grain yield. However, the influence of heat stress on grain yield depends on its timing, duration and intensity. To address these challenges, there is a pressing need for the development of heat-tolerant wheat cultivars. Advancing our understanding of how wheat responds to elevated temperatures and enhancing its tolerance through genetic and agronomic innovations are essential steps toward ensuring sustainable wheat production. In the face of climate change, these efforts are critical to maintaining food security and supporting the livelihoods of millions, particularly in regions like Rajasthan where wheat is an important crop.

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REVIEW ARTICLE

Plant tissue culture techniques for *in vitro* mass multiplication of *Prosopis cineraria* (L.) in Thar Desert of Rajasthan

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Kumar R, Bhandari S, Sarita. Plant tissue culture techniques for *in vitro* mass multiplication of *Prosopis cineraria* (L.) in Thar Desert of Rajasthan. AGBIR.2024;40(4):1185-1187.

Prosopis cineraria (L.) is commonly known as Khejri or Shami. It is a multipurpose tree species found in arid and semi-arid regions of the Indian subcontinent. Its ecological significance includes soil stabilization and nitrogen fixation, while economically, it provides timber, fuelwood and fodder. Medicinally, various parts of the tree are used in traditional remedies for conditions like diabetes and respiratory ailments. Conventional propagation methods for *Prosopis cineraria* are often inadequate for its large-scale production. *In vitro* tissue culture techniques offer a viable alternative for mass multiplication and conservation of this valuable species. This review provides an in-depth analysis of various plant tissue culture methods employed for the *in vitro* propagation of *Prosopis cineraria*. The review also discusses the challenges, optimization strategies and potential applications of these techniques.

Key Words: *Prosopis cineraria; Tissue culture; Cytokinin; Soil*

INTRODUCTION

Prosopis cineraria (L.), commonly known as Khejri or ghaf, plays a significant role in combating desertification in the Thar Desert of Rajasthan [1]. It is a member of the family Fabaceae. It is widely recognized for its adaptability to harsh environmental conditions, making it a keystone species in the Thar Desert and other arid regions. The Khejri tree is unique in that it thrives in all desert climates. It is known as Kalptaru, which means all parts of the tree are useful. It is also referred to as the "wonder tree" and consequently, the "king of desert" [2-4]. Regular surveys conducted in 2010 in Jodhpur, Nagpur, Sikar, Churu and Jhunjhunu by the Arid Forest Research Institute, Jodhpur, revealed that the percentage mortality of Khejri trees ranged from 18.08% to 22.67%, with an average mortality of 20.93% in these districts [5,6]. This resilient tree species is well-adapted to arid and semi-arid conditions, making it an invaluable asset in the efforts to mitigate the adverse effects of desertification. It reduces desertification through soil stabilization, soil fertility improvement, water conservation, support for biodiversity, provision of economic benefits, carbon sequestration and enhancement of ecosystem resilience. Its multifaceted role underscores the importance of conserving and promoting this tree species in arid regions like Rajasthan. The tree is valued for its nutritional, medicinal and ecological benefits. Despite its importance, natural regeneration is slow and overexploitation has led to its decline. Micropropagation is an effective technique for producing disease-free plants quickly, rare species quickly multiplying, genetically modifying plants and producing bioactive substances produced from plants [7,8]. Tissue culture techniques offer a potential solution for the rapid propagation and conservation of *Prosopis cineraria* [9-11].

LITERATURE REVIEW

Tissue culture techniques

Plant tissue culture involves the *in vitro* cultivation of plant cells, tissues or organs under controlled environmental conditions on a nutrient medium. This method allows for the rapid multiplication of plants and is particularly beneficial for the propagation of species that are difficult to propagate by conventional methods.

Explants selection and preparation: For the micropropagation of *Prosopis cineraria*, the selection of suitable explants is critical. Commonly used explants include nodal segments, shoot tips and cotyledonary nodes. Explants must be sterilized to prevent microbial contamination, typically using a combination of alcohol and sodium hypochlorite [12].

Culture initiation and shoot multiplication: Explants are placed on a nutrient medium supplemented with essential macro and micronutrients, vitamins and Plant Growth Regulators (PGRs) such as auxins and cytokinins. Murashige and Skoog (MS) medium is frequently used for initiating cultures due to its comprehensive nutrient composition [13]. The induction of multiple shoots from the explants is achieved by optimizing the concentration and combination of cytokinins (e.g. Benzylaminopurine) and auxins (e.g. Indole-3-acetic acid). A high cytokinin to auxin ratio typically promotes shoot proliferation. Subculturing the explants onto fresh media every 3-4 weeks ensures continuous shoot multiplication. After pruning thorny mature trees of *P. cineraria*, the nodal shoot section was used to generate the highest number of 10-12 shoots on Murashige and Skoog's (MS) medium, which contained 0.1 mg/l Indole-3-Acetic Acid (IAA)+2.5 mg/l Benzylaminopurine (BAP)+additives [14]. For the purpose of standardizing shoot formation in nodal segment of *Prosopis cineraria*, a variety of auxins, including Naphthalene Acetic Acid (NAA), IAA, IBA and 2,4-Dichlorophenoxyacetic acid (2,4-D) and cytokinins, such as kinetin and BAP, were added to Murashige and Skoog's (MS) medium. It was discovered that 3-Indoleacetic Acid (IAA: 3.0 mg/l) combined with kinetin (0.05 mg/l) was the most effective combination for multiple shoot differentiation [9].

Callus induction, somatic embryogenesis and organogenesis: Callus induction is the initial step in many plant tissue culture processes. It involves the formation of an undifferentiated mass of cells (callus) from explants under controlled conditions. Somatic embryogenesis involves the development of embryos from somatic or non-reproductive cells, which can then develop into complete plants. Organogenesis is the process by which explants form organs like shoots and roots. Direct and indirect organogenesis can be induced by culturing explants or calli on media with specific PGR combinations [15].

Root induction, acclimatization and transfer to soil: Once adequate shoot multiplication is achieved, shoots are transferred to a rooting medium. This medium is generally fortified with auxins such as Indole-3-Butyric Acid (IBA) to induce root formation. Rooting efficiency can be enhanced by adjusting the concentration of IBA and other supplements like activated charcoal to reduce phenolic exudation. For the purpose of standardizing root production, a variety of auxins, including NAA, IAA, IBA and 2,4-D and cytokinins, including kinetin and BAP, were added to Murashige and Skoog's (MS) medium. After differentiation, shoot segments were obtained and multiplied by subculturing on 1/2 MS that was devoid of auxins and cytokinins. In white's base medium containing 0.8% agar, 3.0 mg/l Indole-3-Butyric Acid (IBA) and 0.05 mg/l kinetin, shoot segments spontaneously

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produced tap roots within 15-20 days. With 60% of the rooted plants, transplantation to pots with a soil-vermiculite mixture (3:1) was completed effectively in *Prosopis cineraria* [9]. On MS medium with 0.1 mgl^{-1} NAA+1.0 mgl^{-1} BAP+additives, differentiated shoots multiplied most effectively. After extracting the differentiated shoots, the original explant of *Prosopis cineraria* was transplanted six times on new medium in order to produce multiple shoots. After pulsing 100 mgl^{-1} IBA for 4 hours, shoots were rooted by culture on hormone-free half-strength MS medium [14]. The acclimatization stage is significant for the survival of *in vitro* cultured plants. Plantlets with well-developed roots are gradually acclimatized to *ex vitro* conditions by transferring them to soil or a soil-vermiculite mixture under high humidity and controlled temperature conditions. This step involves gradually reducing humidity to adapt the plantlets to ambient conditions.

DISCUSSION

Applications and benefits in the Thar Desert

Ecological restoration: *Prosopis cineraria* is pivotal in combating desertification and restoring degraded lands in the Thar Desert. Its deep root system stabilizes the soil, reduces erosion and improves water retention.

Livelihood support and food for animals: The tree provides various products such as fodder, fuelwood and medicinal compounds, supporting local livelihoods. Its leaves and pods are highly nutritious for livestock, especially during the dry season when other forage resources are scarce.

Soil fertility enhancement: *Prosopis cineraria* enriches soil fertility through nitrogen fixation and leaf litter decomposition, which adds organic matter to the soil. This improves the soil's physical and chemical properties, promoting the growth of other vegetation (Figure 1).

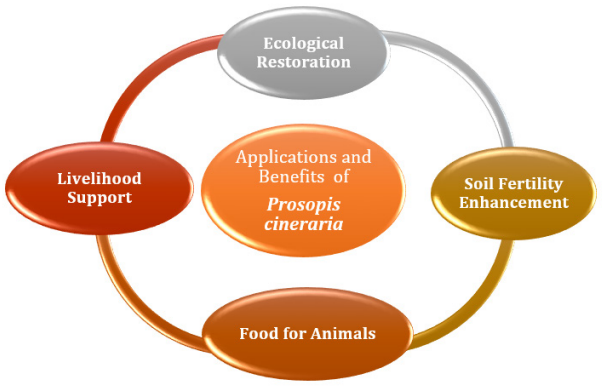


Figure 1) *Applications and benefits of Prosopis cineraria*

Challenges and optimization strategies

Contamination: Contamination is a critical issue in tissue culture, often caused by bacteria, fungi or yeast, which can compromise the culture's success. To address this, surface sterilization of plant material is essential. Mercuric Chloride ($HgCl_2$), though highly effective, is less commonly used due to its toxicity and environmental concerns. Sodium Hypochlorite (NaOCl) is a safer, more widely used alternative, typically applied at 1%-5% concentrations. Both agents work by eliminating surface microorganisms, but proper handling and timing are significant to avoid damaging the plant tissues. Consistent use of these sterilization protocols is key to maintaining aseptic conditions and ensuring culture success.

Somaclonal variation: Somaclonal variation refers to genetic changes that can arise during tissue culture, potentially altering the traits of regenerated plants. This variation may result from stress or genetic instability in the cultured cells. To ensure that tissue-cultured plants maintain the desired genetic characteristics of the parent, regular monitoring is significant. Employing molecular markers such as Polymerase Chain Reaction (PCR) and Simple Sequence Repeats (SSR) allows for precise detection of genetic deviations. These markers help in assessing clonal fidelity, ensuring that the propagated plants are true to type and maintain consistent quality, which is essential for breeding programs and commercial production.

Media optimization: Media optimization is vital for tissue culture success, including macronutrients, micronutrients and Plant Growth Regulators (PGRs), is significant for successful tissue culture. Adjustments must be made continuously based on the type of explant and its developmental stage to promote optimal growth and development.

Acclimatization: Acclimatization involves gradually transitioning *in vitro* plants to *ex vitro* conditions. This process starts with high humidity and reduced light intensity to ease the plants adaptation to external environments. Gradual exposure to these changing conditions helps improve survival rates and ensures a smoother adaptation to natural growth conditions (Figure 2).

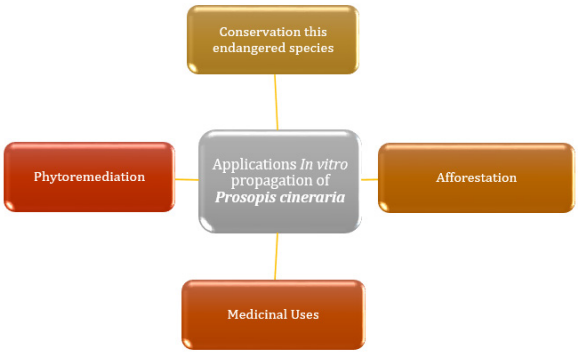


Figure 2) *Applications in vitro propagation of Prosopis cineraria*

Applications

In vitro propagation of *P. cineraria* has numerous applications as follows:

Conservation: *Prosopis cineraria* is a significant species for arid and semi-arid ecosystems, but it is endangered due to habitat loss and other environmental pressures. *In vitro* propagation, which involves growing plants in a controlled, sterile environment, is essential for its conservation. This technique enables the mass multiplication of the species, thus creating large numbers of genetically identical plants that can be reintroduced into their natural habitats. This approach helps in preserving the genetic diversity and ensuring the survival of the species in the wild.

Afforestation: Rapid propagation through tissue culture supports large-scale afforestation projects, especially in arid and semi-arid regions where *Prosopis cineraria* is naturally adapted. By generating a high volume of seedlings quickly and efficiently, *in vitro* propagation facilitates the restoration of degraded lands and contributes to the greening of these challenging environments. This not only helps in combating desertification but also in enhancing local biodiversity and improving soil quality.

Phytoremediation: *Prosopis cineraria* is well-suited for phytoremediation, a process where plants are used to clean up contaminated soils or water. The species' ability to thrive in degraded soils and tolerate harsh conditions makes it a valuable candidate for such projects. *In vitro* propagation ensures a consistent supply of healthy plants that can be used in these remediation efforts, helping to restore soil fertility and remove pollutants from the environment.

Medicinal uses: *Prosopis cineraria* has a history of use in traditional medicine and *in vitro* propagation supports the consistent supply of plant material for the extraction of bioactive compounds. These compounds are used in various medicinal preparations, including treatments for ailments such as inflammation, diabetes and gastrointestinal issues. By providing a steady source of high-quality plant material, tissue culture helps ensure that traditional medicinal practices can continue effectively and sustainably.

CONCLUSION

Prosopis cineraria or Khejri, is a vital species for arid and semi-arid regions due to its ecological, economic and medicinal benefits. Its role in soil stabilization, nitrogen fixation and provision of essential resources underscores its importance in combating desertification and supporting local livelihoods.

However, traditional propagation methods are often inadequate for its large-scale production. *In vitro* tissue culture techniques offer an effective solution for the rapid and disease-free multiplication of *P. cineraria*. These methods, while potential, face challenges such as contamination and somaclonal variation, which require ongoing optimization. Successful implementation of tissue culture can significantly enhance conservation efforts, support afforestation projects and provide a consistent supply of plant material for medicinal uses, thereby ensuring the sustainability and continued utility of this significant species.

Tissue culture techniques offer a sustainable and efficient method for the mass multiplication of *Prosopis cineraria*. Advances in callus induction, somatic embryogenesis, organogenesis and micropropagation have significantly improved propagation efficiency. Despite challenges such as contamination and somaclonal variation, ongoing research and optimization continue to enhance the effectiveness of these techniques. The application of *in vitro* propagation methods can play a pivotal role in the conservation, afforestation and utilization of *Prosopis cineraria*.

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REVIEW ARTICLE

Addressing agricultural waste management challenges: Innovative approaches and best practices

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Pareek S. Addressing agricultural waste management challenges: Innovative approaches and best practices. AGBIR.2024;40(4):1229-1231.

Agricultural waste has become one of the increasing concerns in recent years, as they may cause significant environmental problems; however, they may also use for several beneficial purpose, as feed stock for energy production and for chemical recovery and chemical or dye adsorption. Agricultural wastes including manure, harvest waste, fertilizer run-off, pesticides and silt are produced from agricultural operations. Advancements in technology and sustainable practices have improved waste management with innovative methods like composting, anaerobic digestion and bioconversion offering valuable resources. The integration of Information and Communication Technologies (ICT) can enhance waste management processes. However, agricultural waste can be harmful to the environment and workers and storage can increase hazards by releasing harmful gases. This review is divided into the following four sections: agriculture waste characterization, waste reuse and recycling, waste treatment and waste management and minimization.

Key Words: *Agricultural waste; Waste generation; Waste management; Waste solution*

INTRODUCTION

Agricultural wastes are defined as the residues from the agricultural waste refers to waste that is produced from agricultural operations. Agricultural waste includes manure and other wastes from farms, poultry houses and slaughterhouses; harvest waste; fertilizer run-off from fields; pesticides that enter into water, air or soils; silt drained from fields. Recent advancements in technology and an increasing emphasis on sustainable practices have opened new methods for managing agricultural waste more efficiently. Innovative methods such as composting, anaerobic digestion and bioconversion offer potential solutions for converting waste into valuable resources like fertilizers, bioenergy and animal feed. Moreover, the integration of Information and Communication Technologies (ICT) can enhance waste management processes by providing real-time data, improving resource allocation and facilitating better decision-making.

This paper aims to explore the challenges associated with agricultural waste management and present innovative approaches and best practices for addressing these issues. By examining case studies and successful examples from various regions, we will highlight the potential of modern technologies and sustainable practices in transforming agricultural waste into valuable resources.

The agricultural waste potentially damaging to the environment and also these wastes may expose workers to harmful biological material that is biohazards.

Storing agricultural waste can multiply the hazards associated with it since stored waste can release harmful gases which are not good for health [1].

LITERATURE REVIEW

Agricultural waste generation

Earlier it is noted that agricultural development is usually accompanied by wastes from the irrational application of intensive farming methods and the improper use of chemicals in cultivation, remarkably affecting rural environments in particular and the global environmental in general. The waste generated is dependent on types of agricultural activities carried out.

Wastes from cultivation activities: While tropical climate is good for growing crops, it also supports the generation and development of insects and weeds. This situation creates a high demand for pesticides in order to kill those insects and weeds and protect against the spread of epidemic diseases; this need often lead to the misuse of pesticides by farmers. After using pesticides, most of the pesticides bottles and packages holding these pesticides are thrown into fields or ponds. According to an estimate made by the Plant Protection Department (PPD) about 1.8% of the chemicals remain in their packaging. These wastes have the potential to cause unpredictable environmental consequences such as food poisoning, unsafe food hygiene and contaminated farmland due to their potentially lasting and toxic chemicals. Inorganic fertilizer is inexpensive and characterized by high productivity. However, many farmers apply more fertilizer to their crops than the amount needed by the plants. The rate of absorption of such fertilizer compounds such as nitrogen, phosphorus, potassium, etc. varies depending on the characteristics of land or yield, types of plants and method of fertilization. Among the fertilizer excess, a portion is retained in the soil, a portion enters ponds, lakes and/or rivers as a result of either surface runoff or the irrigation system adopted, which results in the pollution of surface water; a portion enters the ground water and a portion evaporates or becomes de-nitrated, these leads to air pollution [2].

Wastes from livestock production: Waste from farm animal activities include solid waste like manure and organic materials within the slaughterhouse; sewer water like urine, cage wash water, sewer water from the showering of animals and from maintaining sanitation in slaughterhouses; air pollutants like Hydrogen Sulfide (H_2S) and Methane (CH_4) and odours. The pollution caused by livestock production is so significant downsides since most of them are typically designed around residential areas. Air pollution includes odours emanating from cages ensuing from the digestion method of livestock wastes. The intensity of the smell depends on animal density, ventilation, temperature and humidness. The proportion of Ammonia (NH_3), H_2S and CH_4 varies along with the stages of the digestion process and also depends on organic materials, the components of foods, microorganisms and the status of the animal's health. This untreated and non-reusable waste supply will generate greenhouse gases whereas also having negative effects on the fertility of the soil and inflicting pollution. In livestock waste, water volume accounts for 75%-95% of total volume, while the rest includes organic matter, inorganic matter and many species of microorganisms. Those germs and substances will unfold diseases to humans and cause several negative effects on the environment.

Waste from aquaculture: The growth in cultivation has led to a rise within the use of feeds for improved production. The amount of feed employed in a system is the most significant issue employed in decisive the amount of waste generated. One of the key wastes generated in cultivation is metabolic

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waste which could be dissolved or suspended. Feeding rates are dependent on the ambient temperature. Increase in temperature leads to increased feeding which provides rise to increased generated waste. Water flow patterns in production units are vital for waste management as a result of a correct flow can minimize the fragmentation of fish body waste and permit for fast sinking and concentration of the settleable solids. This is vital as a result of a high proportion of non-fragmented body waste can be quickly captured which can greatly reduce the dissolved organic waste.

Problems due to agricultural waste

Health problems: Pesticides, ammonia heavy metals, fertilizers and oils from farms and farm equipment have a serious impact on health when they get into drinking water. People who drink this tainted water take in these harmful substances, which can cause major health issues or even lead to early death. Reports show that nitrates from contaminated water result in blue baby syndrome causing infant deaths.

Other dangerous chemicals like heavy metals can damage vital organs, weaken the immune system and harm the nervous system. Farm waste can also introduce parasites and bacteria into water adding to the spread of diseases and deaths [3].

Reduction in long-term agricultural yields: Farmers keep using pesticides, herbicides and other farm chemicals to fight off pests, weeds and diseases. But many don't know how these harsh chemicals affect their land over time. These strong chemicals stick around in the soil for years. They can pollute water and plants and kill helpful bugs and tiny organisms in the soil.

This has an impact on how fertile the soil is how good the crops and how well nature balances itself. In the long run, it can lead to lower crop yields. Maybe that's why some farmers are going back to old-school manure and organic farming methods [1].

Effect on aquatic life: Agricultural pollution has a major impact on water systems and groundwater, which causes serious harm to aquatic life. Fish and other water-dwelling animals absorb farm chemicals, pesticides and fertilizers which affect their health and ability to reproduce. When surface waters have high levels of nitrogen and phosphorus from fertilizers, manure and animal waste it leads to eutrophication. This process uses up dissolved oxygen killing fish and other aquatic creatures. Other chemical compounds, like heavy metals and ammonia can also hurt aquatic life and cause fish deaths [4].

Eutrophication: Systems, nitrogen and phosphorus from manure and fertilizers cause eutrophication when rain or irrigation washes them into nearby surface waters. Eutrophication is the thick growth of plant life and algae on the water surface and results in lots of algal blooms.

Eutrophication reduces dissolved oxygen, which can kill fish and other water-dwelling creatures. It also has a link to more cases of paralytic shellfish poisoning in humans which can lead to death.

Soil pollution and depletion of soil fertility: Chemical pesticides, herbicides and agrochemicals used to control pests, diseases and weeds often pollute the soil and can stick around for years. This has an impact on soil microbial activities and soil chemistry over time reducing soil fertility by destroying soil microorganisms. Studies show that millions of fertile soils are lost each year due to synthetic fertilizers, pesticides and herbicides along with other farming methods [5].

Water pollution: Farming activities and methods like poor water control and watering cause water pollution from surface runoff affecting both surface and ground water. Using fertilizers, pesticides, manure, weed killers and other farm chemicals results in widespread contamination of waterways and ground waters and lowers water quality. Soil erosion and sediment buildup also pollute the water making it dirty and cloudier. As a result, plants, wildlife, humans, animals and water-dwelling creatures suffer negative effects.

Air pollution: Farm animals and fertilized fields can release a lot of gases into the air. These gases, like nitrogen oxides and ammonia, contain carbon and nitrogen and might contribute to the greenhouse effect. When farmers plow, harvest or use machines like tractors, they burn fossil fuels. This has an impact on greenhouse gas levels. Also, some natural processes in the soil give off many greenhouse gases.

Destruction in biodiversity: The ongoing use of chemical products in farming has a negative impact on and destroys soils, animals, plants, waters and wildlife. This changes the ecosystems that support biodiversity. Also, pesticides can kill helpful insects, soil microorganisms, birds and some uncommon small species like butterflies. This has far-reaching effects on biodiversity [6]. These chemicals stay in the soils for many years, which leads to huge consequences for biodiversity [1].

DISCUSSION

Multifaceted approach as a solution

Watershed efforts: The collaboration of a wide range of people and organizations across an entire watershed is important to cut down on nutrient pollution. State governments, farm groups, nature protection organizations, schools, non-profits and community clubs all play a role in successful efforts to boost water quality.

Nutrient management: Applying fertilizers in the proper amount at the right time of year and with the right method can significantly reduce the potential for pollution.

Cover crops: Planting certain grasses, grains or clovers can help keep nutrients out of the water by recycling excess nitrogen and reducing soil erosion.

Buffers: Planting trees, shrubs and grass around fields, especially those that border water bodies can help by absorbing or filtering out nutrients before they reach a water body.

Conservation tillage: Reducing how often fields are tilled reduces erosion and soil compaction, builds soil organic matter and reduces runoff.

Managing livestock waste: Keeping animals and their waste out of streams, rivers and lakes keeps nitrogen and phosphorus out of the water and restores stream banks.

Drainage water management: Reducing nutrient loadings that drain from agricultural fields helps prevent degradation of the water in local streams and lakes [7].

Preventive measure

Aerobic fermentation (composting method): Turning organic waste into compost for farms is becoming a popular and workable way to handle organic trash. People think composting is the top method for dealing with organic waste. These days, you can compost in open areas using clean organic waste from parks and gardens without needing to add air. You can also do it in closed spaces to speed things up and avoid bad smells. In this case, the waste gets ground up, sifted and mixed first. Benefits and ways to prevent environmental risks are composting helps the environment by cutting down on waste in landfills. It's also good for health because it reduces the chance of germs in waste surviving and spreading [5]. Furthermore, the final product makes great fertilizer for soil. The main advantages and prevention measures of environmental risks of composting technology are as follows:

1. It ensures environmental protection near livestock rearing and also in the whole area in which it applies.
2. It replaces heavy to carry with a concentrated product, easily transportable, odorless, free of pathogens, easy to store, a bulky product with high humidity.
3. The compost is a product able to reduce the deficiency of organic matter and micronutrients in agricultural soils.
4. The use of compost as agricultural soil fertilizer or growing medium has significant environmental benefits. Besides reintegration nutrients in the soil and thus leads to reduction in the favoring of chemical fertilizers used, compost biodegradable waste is no longer reach to the ecological deposit. The greenhouse gases from composting have a low contribution to the global warming because this practice is not yet widespread. Bio-filter in the enclosed composting facilities removes odour emissions [8].

Anaerobic digestion process: Anaerobic digestion is a biochemical process. It breaks down complex organic materials like plant biomass, animal waste organic trash, wastewater and sewage sludge. This happens without oxygen

resulting in biogas and digested matter. Different types of anaerobic bacteria do this work. For years, people have used anaerobic digestion to stabilize sewage sludge. In recent times, this method has grown to treat and recover energy from other wastes. These include animal waste sorted household trash industrial organic waste and factory wastewater [6]. Making biogas through anaerobic fermentation and using it has many upsides. It benefits society as a whole and farmers involved. These benefits are social, economic and environmental they include: renewable energy source; reduced emissions of greenhouse gases and reduce the global warming; contribution of the alignment to the European Union requirements for energy and environmental protection for agriculture; reducing the odours from livestock but also from other organic waste; significant additional source of income for the agricultural sector.

The process of anaerobic digestion has a limited impact on the environment, which is related to the biogas production itself: risk of odours, solved by burning odorous components in the exhaustion air or other odour treatment techniques and risk of explosion, solved by utilization of explosion-proof equipment [9].

Integration of information and communication technologies: Information and Communication Technologies (ICT) can play a critical role in optimizing agricultural waste management processes by providing real-time data, improving resource allocation and facilitating better decision-making. Enhances efficiency and effectiveness of waste management operations through data-driven decision-making. Improves monitoring and tracking of waste generation, collection and processing. Facilitates communication and coordination among stakeholders, including farmers, waste processors and policymaker's real-time data, improving resource allocation and facilitating better decision-making [10].

Policy support and community engagement: Effective agricultural waste management requires supportive policies and active community engagement to ensure the adoption and sustainability of innovative solutions [10]. Creates an enabling environment for the adoption of sustainable waste management practices. Encourages community participation and collaboration in waste management initiatives. Enhances the scalability and impact of waste management solutions.

CONCLUSION

The challenge of managing agricultural waste requires a multifaceted approach to mitigate its adverse effects on the environment and human health. Despite the significant environmental hazards posed by agricultural waste such as soil and water pollution, air contamination and impacts on biodiversity innovative solutions offer potential methods for improvement. Advances in technology, including composting, anaerobic digestion and the integration of ICT, present viable methods for transforming waste into valuable resources. These practices not only help in reducing pollution but also contribute to sustainable agricultural development. Additionally, policy support and community engagement are important for the successful implementation of these solutions. By Encouraging a collaborative approach among stakeholders and leveraging modern technologies, we can address the pressing issues of agricultural waste and work towards a more sustainable and environmentally-friendly agricultural sector. The ongoing development and application of these practices will play a key role in shaping the future of agricultural waste management.

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REVIEW ARTICLE

Use of biofertilizers in modern agriculture

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Verma L, Kumar V. Use of biofertilizers in modern agriculture. AGBIR.2024;40(4):1191-1193.

The fertilizer production in our country is less than the required amount. To fill this gap, alternate sources of nutrients have to be looked for. Organic wastes and biofertilizers are the alternate sources to meet the nutrient requirement of crops and mitigating nutrient deficiencies. Further, knowing the harmful effect of using only the chemical fertilizers on soil health, use of chemical fertilizer along with compost and biofertilizers is required which will help to maintain soil health and productivity. With the introduction of green revolution technologies, the modern agriculture is getting more and more dependent upon the steady supply of synthetic inputs (mainly fertilizers). Adverse effects are being noticed due to the excessive and imbalanced use of these synthetic inputs. This situation leads to identifying harmless inputs like biofertilizers whom use in crop cultivation will help in safeguarding the soil health and also the quality of crop products.

Key Words: *Biofertilizers; Rhizobiu; Phosphate solubilizing bacteria; Potassium mobilizing bacteria; Silicon solubilizing bacteria*

INTRODUCTION

Biofertilizers are the products containing one or more species of microorganisms which have the capacity to mobilize nutritionally important elements from non-usable to usable form through biological processes such as nitrogen fixation, phosphate solubilization, excretion of plant growth promoting substances or cellulose and lignin biodegradation in soil, compost and other environments. These microorganisms, which may include bacteria, fungi or algae, carry out a variety of biological processes that are significant for enhancing soil fertility and plant growth. One of the most significant advantages of biofertilizers is that they are completely harmless to the environment. Unlike chemical fertilizers, which can cause pollution and long-term soil degradation, biofertilizers are natural, non-toxic and sustainable. They contribute to a reduction in the need for synthetic fertilizers, which in turn lowers the risk of groundwater contamination, soil acidification and the depletion of essential soil microorganisms. Moreover, biofertilizers are low-cost renewable agricultural inputs. By improving the availability of nutrients in the soil, biofertilizers support healthier plant growth, higher crop yields and better-quality produce. They play a significant role in improving nutrient availability in plants. They are recognized as a components of integrated plant nutrient supply system [1].

A crop nutrient management plan is a tool that can increase the efficiency of all the nutrient. Nitrogen promotes the vegetative growth and increase protein content in the crop. Phosphorus enhances the activity of rhizobia, increase the formation of root nodules, stimulates early root development, helps in fixing more atmospheric nitrogen and aids in grain formation when applied to legumes. It also improves the crop quality and resistance to disease. Potassium also plays a major role in the transport of water and nutrients for whole of the plant in the xylem. In general, sulphur is required for the synthesis of vitamins and promotes nodulation in legumes. Sulphur is known to play an inevitable and imperative role in sulphur containing amino acids i.e., cysteine, cystine and methionine, vitamin and protein synthesis. The need of nitrogen, phosphorus, potassium and sulphur are determined by the crop [2]. Biofertilizers help in the maintenance or adjustment of plant nutrient supply to an optimum level for sustaining desired crop productivity and soil fertility.

In sandy soils of semi-arid regions, drought stress and lack of nutrients (mainly nitrogen and phosphorus) are considered as the main production constraints. Therefore, guar is expected to fit very well in this region as an important drought tolerant cash crop and soil-building crop, with respect to available nitrogen through nitrogen fixation to maintain soil fertility and sustainable productivity [3].

LITERATURE REVIEW

Liquid biofertilizers are liquid formulations have the dormant form of desirable micro-organisms and their nutrients together with the substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to unfavorable conditions. The dormant form of reaching the soil, germinate to create the fresh batch of active cells. These cells developed and multiply by utilizing the carbon source in the soil or from root exudates. A lot of work done on carrier-based biofertilizers in the context of organic food production. In view of the advantages of liquid biofertilizers over carrier based formulations, research has now been started on the production and testing of liquid biofertilizers. Consequently, liquid biofertilizers are specifically formulated solution that contains beneficial micro-organism which improves nutrient uptake by converting it in soluble form, increase soil fertility, produces plant growth promoting substances and plant hormones thereby reduces chemical fertilizer usage up to 20%-30% [4]. Fungi, bacteria and *Cyanobacteria* are the main source of bioferlizers. Fungi are non-green microorganisms; aside from making phosphorus available in the soil for plant uptake, they help to aggregate the soil structure. *Cyanobacteria* are symbiotically associated with *Azolla* and also known as blue-green algae. Species of blue green algae are Nostoc and *Anabaena*. Examples of fungal biofertilizers are *Mycorrhiza*, *Fusarium* species and *Penicillum* species. Examples of bacterial biofertilizers are *Azotobacter*, *Azospirillum*, *Clostridium*, *Rhizobium* etc. A combination of biological and chemical sources of nitrogen are cheaper and impressive way of increasing production under limited resources [5]. Biofertlizers are applied as grain treatment or applied in the soil. Biofertilizers in liquid formulation are easy to handle and applied at 3-5 ml/kg grain just before sowing. Soil applied biofertiizers are mixed in compost or farm yard manure and kept it for overnight and then incorporated in soil just before sowing. Now a days in addition to Nitrogen (N), Phosphorus (P) and Potassium (K) fixing biofertilizer, liquid bifertilizers for sulphur, zinc and manganese are also available. These liquid biofertilizers are easy to handle and cost effective [6]. In India, biofertilizers are available for almost all crops. Hence, total consumption of biofertilizer is expected to increase too many fold in coming years. Various Agricultural State Universities and non-Government Organizations are engaged in mass production of biofertilizers [7-9]. Largest producing states are Madhya Pradesh, Maharashtra, Karnataka and Tamilnadu. The biofertilizer demand in India is several thousand tones, but no sufficient production facilities are available.

Characteristics of liquid biofertilizers

Dormant microorganisms: In their dormant state, these microorganisms can survive in the liquid formulation and remain viable until they are introduced

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into the soil. Upon reaching the soil, they reawaken, germinate and multiply, utilizing available carbon sources from the soil or root exudates to become active.

Extended shelf life: Liquid biofertilizers typically have a shelf life of 12 to 24 months, which is significantly longer than that of traditional carrier-based biofertilizers. This extended shelf life is due to the dormant state of the microorganisms and the formulation's stability.

Temperature tolerance: They can withstand higher temperatures up to 45°C without losing their efficacy, which is not the case for many carrier-based products.

Low contamination risk: The liquid format minimizes the chances of contamination compared to carrier-based biofertilizers.

High population density: Liquid biofertilizers can maintain high populations of beneficial microorganisms, often exceeding 10^9 cells per unit, ensuring effective inoculation and impact.

Reduced dosage: The required dosage for liquid biofertilizers is about ten times less than that of carrier-based inoculants, making them more efficient and cost-effective.

Quick quality control: The liquid formulation simplifies quality control procedures, making it easier to ensure product consistency and effectiveness.

Seed treatment

Nitrogenous biofertilizers: Apply at 200 gm/10 kg seeds.

Phosphatic biofertilizers: Apply at 200 gm/10 kg seeds.

Liquid biofertilizer: Dip seeds in a solution of 3 ml of liquid biofertilizer per liter of water.

Soil treatment

4 kg each of the recommended biofertilizers are mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

DISCUSSION

Challenges of biofertilizers development and use

Biofertilizers represent a biological approach aimed at the sustainable intensification of agriculture, offering an eco-friendly alternative to synthetic fertilizers. Despite their potential benefits, several challenges hinder their widespread application and effectiveness in boosting agricultural yields.

Variable performance under field conditions: Biofertilizers are highly sensitive to both biotic and abiotic stresses. While they may demonstrate promising results in laboratory and greenhouse settings, their performance often varies significantly in actual field conditions. Crops are grown in diverse environments with varying temperatures, rainfall, soil types, soil biodiversity and crop varieties. These environmental variations can lead to inconsistencies in the efficacy of biofertilizers, making it challenging to ensure reliable results across different settings.

Slower action compared to synthetic fertilizers: Biofertilizers generally act more slowly than synthetic fertilizers. The inoculum in biofertilizers needs time to establish itself, build up its population and effectively colonize plant roots. This delayed action can impact their adoption among farmers who may be accustomed to the immediate results provided by synthetic alternatives.

Need for field-specific research: To address these challenges, it is essential to select potential biofertilizer isolates based on their performance under various field conditions. This involves testing them across multiple crops, soil types and environmental conditions to identify those that offer consistent benefits. Biofertilizers should ideally complement rather than completely replace synthetic fertilizers, helping to reduce their usage and associated environmental impacts.

Shelf life and storage issues: Biofertilizers contain live microbial cells, which pose challenges related to shelf life and storage. Typically, they have a short shelf life of around six months when stored at 20°C-25°C. This necessitates careful handling, transportation and storage to maintain their viability, which can increase product costs and limit availability, especially in remote rural areas.

Regulatory and standardization barriers: The development and commercialization of biofertilizers face regulatory hurdles, including difficulties in product registration and patenting. One major issue is the lack of standardized legal and regulatory definitions for terms such as "plant biofertilizer" or "plant biostimulant". This absence of a globally coordinated regulatory framework creates inconsistencies and barriers to market entry, complicating the commercialization process [10-12].

Future prospects of biofertilizers

There is a growing demand for agricultural goods produced in a sustainable manner; therefore, the use of eco-friendly inputs for food production, such as biofertilizers, will have a significant increase in the coming years. The global market of biofertilizers is expected to increase from 2.3 billion US dollar in 2020 to 3.9 billion in 2025. The increase in the market value will be supported by government agencies and industry to create awareness among farmers and consumers about the benefits of the use of biofertilizers, in concordance with the development sustainable goal 12 proposed by FAO: "ensure sustainable consumption and production patterns. The role of metagenomics to have a better understanding of microbial communities associated with rhizosphere is a growing field of research and it will continue to increase. Plant rhizosphere is colonized by a large number of microorganisms and this results in a huge number of microbial genes that interact with plant genes. However, more elaborated research has to be conducted, such as meta transcriptomic and meta proteomics and their relation with plant growth. The results of the omics must be translated into the field to have better agronomic practices and new biofertilizer formulations.

CONCLUSION

In conclusion, the increasing reliance on chemical fertilizers in modern agriculture has raised significant concerns regarding soil health, environmental impact and the long-term sustainability of farming practices. To reduce this, the integration of biofertilizers, which are eco-friendly and renewable, offers a potential solution. Biofertilizers, derived from naturally occurring microorganisms, contribute to maintaining soil fertility, promoting healthier crop growth and reducing the negative environmental effects linked to synthetic fertilizers. Despite challenges such as variability in field performance, slower nutrient release and regulatory hurdles exist, the potential of biofertilizers remains positive. The growth will be supported by ongoing research and technological advancements that aim to improve the efficiency and reliability of biofertilizers. By harnessing the benefits of biofertilizers and overcoming existing challenges, they can play a pivotal role in sustainable crop production, soil health preservation and environmental protection, making them an indispensable component of future agricultural strategies.

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REVIEW ARTICLE

Nitrogen management in maize in semi-arid region

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Verma L, Kumar V. Nitrogen management in maize in semi-arid region. AGBIR.2024;40(4):1188-1190.

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions and successful cultivation in diverse seasons and ecologies for various purposes. Globally, maize is known as "Queen" of cereals because it has the highest genetic yield potential among the cereals. Maize is also known as *Drosophila* of crops. It efficiently utilizes solar energy and has immense potential for higher yield, so called as "Miracle crop". Maize ranks third in India in terms of production among cereals, among the three major fertilizers, nitrogen, phosphate and potassium, application of nitrogenous fertilizers is the maximum. It is reported that China, India and Pakistan together consume approximately 70% of nitrogen fertilizer consumed globally. These figures of nitrogen fertilizer consumption point towards emerging environmental pollution issues.

Key Words: *Leaf colour chart; Maize; Nitrogen use efficiency; Split application*

INTRODUCTION

In this study, Nitrogen (N) application to maize tended to improve vegetative growth. The response to nitrogen increased as level of nitrogen applied increased. Thus it is feasible to recommend nitrogen application to maize under similar conditions. In our survey area, the main fertilizer used at seeding is Diammonium Phosphate (DAP) and the main topdressing fertilizer is nitrogen, including predominant use of urea and ammonium bicarbonate. Potassium fertilizer application has been largely ignored on grain crops. Urea and other nitrogenous fertilizers are the need of the hour due to increased population and nutritional demand, but not at the cost of environmental health and life of living organisms. The blind use of nitrogenous fertilizers is only due to lack of scientific knowledge and awareness, poor management practices, greediness and illiteracy among farmers [1].

In case of semi-arid regions, due to high accumulation of soil NO_3-N were indicated the leaching losses by the excessive nitrogen applications and residual soil NO_3-N contents after harvest and apparent nitrogen losses markedly increased with increased nitrogen fertilizer rate. Excessive use of nitrogenous fertilizers and other chemical fertilizers affect these invaluable soil microflorae and the result is unproductive land with less or no water holding capacity increases tissue succulence in crop plants and make them susceptible to diseases and pests. The increased condition succulence of plant tissues helps in pests and pathogens entry and multiplication easier therefore increasing the susceptibility. The nutrients lost by runoff and leaching due to excessive application of chemical fertilizers also adds to environmental pollution. This excess nitrogen reaches water bodies destroying flora and fauna and causes many deadly diseases to human beings and water and air contaminated [2].

LITERATURE REVIEW

In recent years concern has grown over the contribution of Nitrogen (N) fertilizers to the environmental problems of nitrate pollution of waters and the pollution of the atmosphere with nitrous oxide, other oxides of nitrogen and ammonia. considering of these concerns, proposals to mitigate these problems have been considered and others will be advancing. When they have been used in high amounts, fertilizers and animal manures have created problems of nitrate pollution. Nitrous oxide (N_2O) is a greenhouse gas and may also contribute to the destruction of the stratospheric ozone when it is converted to nitric oxide. N_2O is primarily produced in the biological processes of nitrification and denitrification. Nitric oxide and nitrogen dioxide are also produced in biological processes and are important in atmospheric reactions in the troposphere and stratosphere. There is little indication that nitrogen fertilizers contribute very much to the production of nitrous oxide.

More research is needed to characterize and measure the emissions of the oxides of nitrogen and ammonia and to make better estimates of global emissions based on process-related models. More efforts to increase the efficiency of nitrogen fertilizer use through modifications or use of inhibitors of biological processes as well as better management of rates, timing and incorporation are needed to ensure increased food production while conserving natural resources. Different agronomic options are being recommended which make a way of precision application of nitrogen by using split application at different stage of crop cycle.

Further leaf colour chart and Normalized Difference in Vegetative Index (NDVI) and pursue usefulness for real time nitrogen management by matching time of fertilizer application with maize plant need. Leaf Color Chart (LCC) for maize is under development and being standardized for a number of varieties by Punjab Agricultural University (semi-arid region), Ludhiana. By matching the leaf color of their crop from 10-12 randomized sites in their field (by passing the diseased plants) with the color of chart; farmers can find the required dose of fertilizers application at specific site or plant. By using standard leaf color chart we can predict the amount of nitrogen required in the field or the individual plant [3]. This will have a check on the undue use of urea in the field.

Recent methods of application like fertigation would help in increasing the nutrient use efficiency along with reducing the losses. Fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer solution is distributed evenly in irrigation. The availability of nutrients is very high therefore the efficiency is more. In this method liquid fertilizer as well as water soluble fertilizers are used. By this method, fertilizer use efficiency is increased from 80%-90%. Practicing fertigation is beneficial to farmers in timely and site specific application of nutrients. Application of exact quantity of fertilizers according to soil nutrient status based on soil tests will not only result in proper supply of deficient nutrient elements essential for profitable crop production but also saves cost by supply of precise amount of nutrients as per the nutrient supplying capacity of the soil. New schemes like soil health cards (launched in February, 2015) by the government of India to improve the soil health of the individual farmer's land. Advice on handling particular kinds of soil are then handed over in form of soil health cards to the farmers to serve as a guiding tool to apply fertilizers for various crops. Mobile van soil testing facility is also available under the scheme [4].

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Split Nitrogen (N) fertilizer applications can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible. Dividing total nitrogen application into two or more treatments can help growers enhance nutrient efficiency, promote optimum yields and mitigate the loss of nutrients. Study in Marathwada region have shown that splitting of total recommended nitrogen into three equal proportions and applying as basal, 30 Days After Sowing (DAS) and at 60 DAS found to produce highest yield attributes along with high Nitrogen Use Efficiency (NUE) and observed that band placement of the fertilizer showed the better results, instead of other methods. Band placement reduce the denitrification, volatilization and leaching losses. By more specifically synchronizing nitrogen supply with a plant's ability to utilize nutrients, split application can be an important component of 4R nutrient stewardship-right source, right rate, right time and right place. Depending on soil type, climate, agronomic practices and other factors, nitrogen fertilizer can be vulnerable to loss. Denitrification, leaching and volatilization impose costs that include lost productivity and negative environmental impact. Split-applying nitrogen fertilizer is one way to confront these challenges. When a crop's total nitrogen requirement is supplied with a single pre-plant or at planting application, most of the nitrogen must wait for the target crop's future needs and that means the window for potential loss remains open longer. By postponing a portion of the nitrogen treatment until the crop is better able to utilize the nutrient, plants take up the nitrogen more quickly and efficiently. That means growers get more from their fertilizer investment and fertilizer losses that can contribute to environmental concerns are lessened [5].

DISCUSSION

Enhanced nitrogen efficiency with split applications

Agriculture faces the daunting challenge of meeting food, forage and fiber needs in a manner that is both environmentally and economically sustainable while striving to increase productivity with more efficient use of resources. Fertilizer is an integral part of this quest and the adoption of research-based Best Management Practices (BMPs), such as split fertilizer application, reward farmers and consumers alike. To "split-apply" nitrogen, growers make two or more fertilizer applications during the growing season rather than providing all of the crop's nitrogen requirements with a single treatment prior to or at planting. When all of the nitrogen is supplied ahead of crop growth, more of that nitrogen is susceptible to denitrification, leaching or volatilization. Different growing environments pose different potential nitrogen loss conditions nitrogen leaching beyond the root zone for instance, is most likely in lighter textured soils not inhibited by a clay layer but almost all growers face the possibility of losing some of the nitrogen they apply. By splitting the nitrogen application and put a portion on later, almost all of that second application will be taken up by the plant [6].

Consider split application crop-by-crop

Split application offers efficacy benefits on a wide range of crops and forages but its management must be considered on a crop-by-crop basis. The timing of post-planting nitrogen applications is especially critical. The target species must be immature and growing to provide time for the nitrogen to be absorbed and metabolized in order to have the most efficient yield or quality impact. In the case of corn, for instance, all of the nitrogen should be delivered to the plant before ears are set. All crops however, have different nutrient requirements. Because of a need for continuous, in-season production, forages especially benefit from split-applying nitrogen.

Source and placement important

As in all fertilization strategies, source, rate, time and place should be the foundation of split fertilization decisions. Although various forms of nitrogen granular, liquid and anhydrous can be utilized in a split application scenario, their placement is critical. Anhydrous for example, can be used on row crops but should be injected into the soil and therefore, protected from loss. Urea spread over the top for the second in-season application is vulnerable to surface volatilization. Just like the crops they nourish, different nitrogen sources have different characteristics. Ammonium forms are less likely to emit Greenhouse Gases (GHG) and are less vulnerable to denitrification than are nitrate fertilizers. Preferably, urea-containing fertilizers should be applied when soil incorporation by rainfall or irrigation is likely within 24-48 hours, or incorporated by tillage. This is especially important in environments favorable to ammonia volatilization.

Better yields, less nitrogen loss

We get a lot of denitrification in our area and if we don't use the nitrogen, we lose it. By putting nitrogen on when the plant can fully utilize it, we get better efficiency and we see better yields. When that corn plant is about 10-12 inches tall, it's at a stage that it's really ready to charge. It's really ready to take advantage of the nitrogen and it's going to use it up. The first split application is applied, in the form of anhydrous, as close to planting as possible in order to minimize nitrogen losses. A starter is used through the planter and the application at 10-12 inches provides the final boost for optimum yields.

Use research-based recommendations

Split application should not exceed total test-based nitrogen recommendations. While split-applying nitrogen can enhance efficiency, it does not change what the plant needs and should not be used to exceed recommendations. Split fertilizer application can be an important part of a successful nutrient management program and can help growers achieve 4R concept. Farmers should consult local or regional agronomic research to identify the Best Management Practices (BMPs) involved with split application as well as its specific use and benefits for the crops they grow. Hence farmers are guided by own wisdom and practices of fellow farmers when it came to application manures and pesticides. They often have no idea what is the soils inherent capacity to supply nutrients and at what it is deficient in and often end up following the wrong practices. Hence, it is very essential to have knowledge on economic and efficient use of nitrogenous fertilizers so that many adverse effects of excess nitrogen usage on living organisms may be avoided without compromising on yield. A large number of new technologies have evolved and are continuously being used in educating farmers on economic use of nitrogen fertilizers and some of these tools and techniques are discussed below for the benefits of farmers. In advance more research work including breeding and technical aspect is required for sustainable maize production with efficient nitrogen management without degradation of environmental components. Plant breeding can be a powerful tool to bring "harmony" between agriculture and the environment, but partnerships and cooperation are needed to make this a reality. The opportunities to improve nitrogen management as producing more efficient plants and more efficient management [7-9].

Research is needed to better understand and manage microbial mediated processes, e.g. the manipulation of Microbial Inoculant Technology (MIT) and dissimilatory nitrate reduction to ammonia to reduce denitrification and conserve nitrogen. Sensors to measure real-time nutrient availability driving multi-nutrient decision support systems linked to precision application would improve nutrient use in conventional farming and plant breeding for NUE, especially for better root distribution and nutrient uptake rather than just yield, would benefit all farm systems. Nutrient management on farms is under the control of the land manger, the most effective of whom will already use various decision supports for calculating rates of application to achieve various production targets. Increasingly, land managers will need to conform to good practice to achieve production targets and to conform to environmental targets if they are to achieve the objective of sustainable farm systems. follow the balanced nutrition practices and applying the proper rate of nitrogen has a greater influence on drainage water nitrate losses than any other nitrogen management factor including application timing, placement, source or nitrification inhibitors. Many studies show drainage nitrate concentration and loading decrease as nitrogen fertilization rate decreases and improving the nutrient management by the strategic approaches, precision farming and nitrification inhibitors [10].

CONCLUSION

In conclusion, Maize (*Zea mays* L) is a highly adaptable and productive crop with significant genetic yield potential, making it a key player in global cereal production. However, the extensive use of nitrogen fertilizers, particularly in countries like China, India and Pakistan, raises significant environmental risks, including water pollution and greenhouse gas emissions. This study underscores the importance of optimizing nitrogen use through split applications and precision methods to enhance NUE while mitigating adverse environmental impacts. Split nitrogen application, when timed appropriately, can maximize nutrient uptake and reduce losses through denitrification, volatilization and leaching. Incorporating tools like the LCC and adopting advanced techniques such as fertigation can further

improve nutrient management. Additionally, research into MIT and real-time nutrient sensors can provide valuable insights and support precision agriculture practices. Effective nutrient management ensures higher yields while protecting environmental health, aligning agricultural productivity with ecological stewardship.

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RESEARCH ARTICLE

Enhancing soil fertility, yield and quality in green gram (*Vigna radiata* L. Wilczek) through integrated nutrient management

Vijay Kumar*

Kumar V. Enhancing soil fertility, yield and quality in green gram (*Vigna radiata* L. Wilczek) through integrated nutrient management. AGBIR.2024;40(5):1308-1310.

A field experiment was conducted at on clay loam soil. The experiment was laid out according to factorial randomized block design with three replications. The experiment comprised four fertility levels (75% Recommended Dose of Fertilizers (RDF), 75% RDF+Vermicompost (VC) at 2 t ha^{-1}, 100% RDF and 100% RDF+VC at 2 t ha^{-1}) and four biofertiliizers levels (control, *Rhizobium*, Phosphate Solubilizing Bacteria (PSB) and *Rhizobium*+PSB) were applied to the green gram variety SML-668. The RDF was 20 kg Nitrogen (N_2) and 40 kg Phosphorus Pentoxide (P_2O_5) per hectare. The soil of the experimental site was clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium and Diethylene Triamine Pentaacetic Acid (DTPA) extractable micronutrients sufficiently above the critical limits. The main findings of investigation are summarized as: The application of fertility level significantly increased the dry matter accumulation, number of pods per plant, number of seeds per pod, chlorophyll content, seed and haulm yields, nitrogen, phosphorus, potassium, copper, zinc, iron and manganese content and uptake in seed and haulm, protein content in seed, number of total and effective root nodules, fresh and dry weight of root nodules, leghemoglobin content in root nodules and net returns up to 75% RDF+VC at 2 t ha^{-1} however, their further increase with application of 100% RDF+VC at 2 t ha^{-1} was non-significant. The increase in test weight was found non-significant. The organic carbon, available nitrogen, phosphorus, potassium, copper, zinc, iron and manganese in soil increased significantly with the application of fertility levels at harvest of the crop, but Electrical Conductivity (EC) and pH remain non-significant. Seed inoculation with *Rhizobium*+PSB significantly increased the dry matter accumulation, number of pods per plant, number of seeds per pod, chlorophyll content, seed and haulm yields, nitrogen, phosphorus, potassium, copper, zinc, iron and manganese content and uptake in seed and haulm, protein content in seed, number of total and effective root nodules, fresh and dry weight of root nodules, leghemoglobin content in root nodules and net returns and the test weight and harvest index were found non-significant. The organic carbon, available nitrogen, phosphorus, potassium, copper, zinc, iron and manganese in soil significantly increased with inoculation of *Rhizobium*+PSB at harvest stage of the crop, but EC and pH remain non-significant. The interactive effect of fertility levels and biofertilizers significantly influenced the seed and haulm yield, nitrogen, phosphorus, potassium uptake by seed and net returns and maximum being with the application of 100% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB combination (F_4B_3), which was at par with 75% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB combination (F_2B_3).

Key Words: *Greengram; Integrated nutrient management; Fertility; Biofertilizer;* Rhizobium

INTRODUCTION

Green gram (*Vigna radiate* L. Wilczek) commonly known as mung bean and golden gram, is one of the important kharif pulse crop. It ranks third among all pulses grown in India after chickpea and pigeon pea. It is quite versatile crop grown for seeds, green manure and forage; as mixed or sole crop either on residual moisture of the previous crop or as a catch crop to make use of the land left fallow between two main season crops. It makes a good manure if incorporated into soil. Further, it enriches the soil by atmospheric nitrogen fixation through root nodules. The crop gives such a heavy vegetative growth and covers the ground so well that it checks the soil erosion in problem areas and can later be ploughed down for green manure. It has considerable potential as an alternative pulse crop in dry land farming. This crop is of great importance because of availability of short duration (65-70 days), high yielding and quick growing varieties [1].

In India, mung bean growing states are Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Odisha. Rajasthan ranks first in area, while Maharashtra ranks first in production. Kerala is the leading state in productivity with an average of 824 kg ha^{-1} whereas, the national average is 548 kg ha^{-1}. Although green gram is a legume and capable of fixing atmospheric nitrogen, still it responds to small quantity of nitrogenous fertilizers applied as starter dose. In terms of significance, phosphorus is most indispensable mineral nutrient for pulse crops as it helps in better root growth and development and thereby making them more efficient in biological nitrogen fixation. Phosphorus is an essential constituent of nucleic acids such as Ribonucleic Acid (RNA) and Deoxyribonucleic Acid (DNA), Adenosine Diphosphate (ADP) and Adenosine Triphosphate (ATP), nucleoproteins, amino acids, proteins, phosphatides, phytin, several co-enzymes *viz.* thiamine, pyrophosphate and pyrodoxyl phosphate [2,3].

MATERIALS AND METHODS

In order to determine the physico-chemical properties of soil, soil samples (0 cm-15 cm depth) were collected from different spots of the experimental field prior to sowing and fertilization. A representative composite soil sample was prepared by mixing all these samples together. The soil sample after drying was passed through 2.0 mm sieve and then subsequently used for mechanical, physical and chemical analysis. The experimental site soil was clay loam in texture, slightly alkaline in reaction. The soil was medium in available nitrogen, phosphorus while high in potassium and sufficient in DTPA extractable micronutrients.

To assess the fertility status of soil, the soil sample (0 cm-15 cm depth), from each plot at harvest of crop was taken. The samples were passed through 2 mm plastic sieve to avoid metallic contamination. The soil sample were analysed for EC, pH and Organic Carbon (OC) and available Nitrogen, Phosphorus, Potassium (NPK) and cationic micronutrients (Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn)) content as per methods [4].

The experiment was laid out in factorial randomized block design with three replications. The treatment combinations were randomized with the help of randomization technique.

Treatment application

Fertility levels: Nitrogen and phosphorus were applied through urea and Diammonium Phosphate (DAP), respectively as per treatments as basal doses at the time of sowing. Whole amount of vermicompost as per treatment was broadcasted uniformly at the time of sowing and incorporated in the soil.

Biofertilizer levels: The required seeds were treated with bavistin at 2 g/kg

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of seed to control seed borne diseases. Later on seeds were inoculated with *Rhizobium* and PSB culture or both as per treatments, using standard method and dried in shade.

Seed rate and sowing

The seeds were sown by 'kera' method with row spacing of 30 cm by hand plough at a depth of 5 cm using a seed rate of 20 kg ha^{-1}. The variety of green gram (SML-668) was used as the test crop and the sowing was done on 18 July 2015.

Thinning, hoeing and weeding

To maintain uniform plant, stand at an intra-row spacing of 10 cm, extra plant was thinned out 10 days after sowing (DAS). In order to minimize weed competition, weeding and hoeing was done manually 19 and 28 days after sowing to facilitate aeration and removal of weeds.

Harvesting

The crop was harvested from net plot area separately from each plot. The harvested material of each plot was tied up in bundles and tagged.

Statistical analysis

Analysis of variance and test of significance: In order to test the significance of variation in experimental data obtained for various treatment effects. The critical differences were calculated to assess the significance of treatment mean wherever the 'F' test was found significant at 5% level of probability. To elucidate the nature and magnitude of treatment effects, summary tables along with Standard Error of the mean (SEm) ± Critical Difference (CD) (p=0.05) were prepared and are given in the text of the chapter "results" and their analyses of variance are given in appendices at the end.

Economics of treatments: The economics of treatments is the most important consideration making any recommendation to the farmers for its wide adoption. For calculation of economics, the average treatment yield along with prevailing market rates for inputs and outputs were used. Hence, to evaluate the effectiveness and profitability of the treatments comprehensive economics including net returns and Benefit cost (B/C) ratio was calculated so that most effective and remunerative treatment could be recommended. The details of calculation are given in appendices at the end [5-7].

RESULTS AND DISCUSSION

The data related to various criteria used for treatment evaluation were analysed statistically using standard statistical methods to test their significance. The data regarding the effect of fertility and biofertilizer levels on net return and benefit cost ratio of green gram are being summarized in Table 1.

Net return

Effect of fertility levels: A perusal of data in Table 1, revealed that with the application of fertility levels, the net return under 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) treatments significantly increased as compared to 75% RDF. However, the increase in net return with 100% RDF+vermicompost (2 t ha^{-1}) was statistically at par with 75% RDF+vermicompost (2 t ha^{-1}). The application of 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) increased the net return to the tune of 28.98%, 14.51% and 36.63% respectively, over 75% RDF [8-10].

Effect of bioferilizers: A critical examination of data in Table 1, revealed that due to inoculation of green gram seed with *Rhizobium*, PSB and *Rhizobium*+PSB, the net returns significantly increased in comparison to control. Further, the increase in net returns with *Rhizobium*+PSB was statistically significant over *Rhizobium* as well as PSB inoculations. However, the increase in net returns with inoculation of *Rhizobium* was statistically at par with that of PSB. The extent of increase in net return of green gram with *Rhizobium*, PSB and *Rhizobium*+PSB inoculation was 38.31%, 33.14% and 54.57% respectively over control.

Interactive effective of fertility and biofertilizer levels: The interactive effect of fertility and biofertilizer levels on the net returns was found significant (Table 2). The significantly highest net returns were obtained under treatment combination F_4B_3, which was at par with the treatment combinations of F_2B_3. Minimum net returns were recorded under F_1B_0 treatment.

Benefit cost ratio

Effect of fertility levels: The benefit cost ratio under 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) treatments significantly increased as compared to 75% RDF treatment. The highest B/C ratio (1.80) was recorded with 100% RDF+vermicompost (2 t ha^{-1}). The application of 75% RDF+vermicompost (2 t ha^{-1}), 100% RDF and 100% RDF+vermicompost (2 t ha^{-1}) increased the B/C ratio to the extent of 9.32%, 8.07% and 11.80% respectively, over 75% RDF.

Effect of bioferilizers: Due to inoculation of green gram seed with *Rhizobium*, PSB and *Rhizobium*+PSB, the B/C ratio significantly increased in comparison to control. The highest B/C ratio (2.08) was obtained with B_3 (*Rhizobium*+PSB). However, the increase in B/C ratio with inoculation of *Rhizobium* was statistically at par with that of PSB. The extent of increase in B/C ratio with *Rhizobium*, PSB and *Rhizobium*+PSB inoculation was 36.23%, 31.16% and 50.72% respectively, over control [11,12].

The application of 100% RDF+VC at 2 t ha^{-1} to green gram crop significantly increased the net return (38837) and B/C ratio (1.80) over others levels of RDF and vermicompost. Likewise, inoculations of greengram seeds with *Rhizobium*+PSB also significantly increased net returns (40102) and B/C (2.08) ratio over *Rhizobium*, PSB and control (Table 1). It is clear that in both the treatments there was significant increase in seed and haulm yield which ultimately gave more net returns and B/C ratio over the input cost incurred in these treatments in comparison to others treatments. These results are in close conformity with those of Meena et al., [13].

Interactive effect of fertility and biofertilizer levels: The significantly highest net returns (48109 ha^{-1}) and B/C ratio (2.22) were obtained with combined use of 100% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB (F_2B_3), which were significantly higher as compared to other treatment combinations (Table 2). However, it is at par with F_2B_3 (44987 ha^{-1}). It is obvious because the seed and haulm yield of green gram also increased significantly under this treatment which is main contributor to net returns and thus resulted in higher net returns under application of 100% RDF+VC at 2 t ha^{-1} and *Rhizobium*+PSB. These results are in close conformity with those of Meena et al., [13].

TABLE 1

Effect of fertility and biofertilizer levels on net returns and benefit cost ratio

Treatments	Net returns (ha^{-1})	B/C ratio
Fertility levels		
F_1: 75% RDF	28424	1.61
F_2: 75% RDF+VC (2 t ha^{-1})	36661	1.76
F_3: 100% RDF	32549	1.74
F_4: 100% RDF+VC (2 t ha^{-1})	38837	1.8
SEm ±	1422	0.04
CD (p=0.05)	4108	0.12
Biofertilizer levels		
B_0: Control	25944	1.38
B_1: *Rhizobium*	35882	1.88
B_2: PSB	34543	1.81

B_3: *Rhizobium*+PSB	40102	2.08
SEm±	1422	0.04
CD (p=0.05)	4108	0.12

Note: RDF: Recommended Dose of Fertilizers; VC: Vermicompost; SEm: Standard Error of the mean; CD: Critical Difference; PSB:Phosphate Solubilizing Bacteria; B/C: Benefit cost.

TABLE 2

Interactive effect of fertility and biofertilizer levels on net returns (ha^{-1})

Treatments	F_1	F_2	F_3	F_4
B_0	24455	26563	25778	26980
B_1	29507	38570	34274	41178
B_2	29106	36524	33462	39081
B_3	30630	44987	36681	48109
SEm ±	2845	-	-	-
CD (p=0.05)	8216	-	-	-

Note: SEm: Standard Error of the mean; CD: Critical Difference.

CONCLUSION

On the basis of one-year field experimentation, it can be concluded that under agro climatic condition of Kanpur, application of 100% RDF+VC at 2 t ha^{-1}+*Rhizobium*+PSB (F_4B_3), is the better option for realizing higher productivity, content and uptake of nutrients, net returns and B/C ratio of green gram and is the better option for improved fertility status of soil. A significant response to the application of aforesaid treatment was observed. However, highest economic green gram seed yield (1386.07 kg ha^{-1}) and net return (48109 ha^{-1}) was observed in treatment combination of F_4B_3 (100% RDF+VC at 2 t ha^{-1}+*Rhizobium*+PSB) with B/C ratio of 2.22, which was at par with F_2B_3 (75% RDF+VC at 2 t ha^{-1}+*Rhizobium*+PSB). The result of the present investigation reveals the significance of fertility levels with the combination of vermicompost and biofertilizer levels in green gram crop for maximization of yield and profits.

However, the highest available nitrogen, phosphorus, potassium, copper, zinc, iron and manganese status of soil after harvesting of green gram crop were observed under fertility level 100% RDF+VC at 2 t ha^{-1} (F_4) and inoculation of *Rhizobium*+PSB (B_3) treatment as compared to 75% RDF (F_1) and control (B_0), respectively.

However, these results are only indicative and require further experimentation for confirmation before making final recommendation to the farmers.

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RESEARCH ARTICLE

Integrated disease management of sclerotinia rot of chickpea (*Cicer arietinum*) incited by *Sclerotinia sclerotiorum* (Lib.) de Bary

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Kumar V. Integrated disease management of sclerotinia rot of chickpea (*Cicer arietinum*) incited by *Sclerotinia sclerotiorum* (Lib.) de Bary. AGBIR.2024;40(5):1318-1321.

Chickpea is an annual legume crop grown in temperate and subtropical regions. It belongs to the Fabaceae family and is native to Southwest Asia. Chickpea have been cultivated since ancient times in both Asia and Europe. India stands as the largest producer and consumer of chickpea globally, contributing roughly 75% of the world's total production. It is primarily consumed in various processed forms, such as boiled, roasted, fried or steamed whole seeds as well as in the form of dal and dal flour. They are commonly used in the preparation of snacks, sweets and condiments. Chickpea crop is prone to various diseases like, dry root rot (*Rhizoctonia bataticola*), Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*), wet root rot (*Rhizoctonia solani*), collar rot (*Sclerotium rolfsii*), Aschochyta blight and Sclerotinia rot (*Sclerotinia sclerotiorum* (Lib.) de Bary). Among various diseases, Sclerotinia rot, also known as stem rot, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, is one of the most significant. It causes substantial yield losses, especially in cool and moist areas conducive to its development. The fungus's explosive pathogenicity and the resilience of its sclerotia contribute to its success as a pathogen. Due to its strict soil-borne nature and wide host range, managing this disease through host resistance or chemical management alone is challenging. Fungicides are commonly used to control plant diseases, but they pose environmental and health risks and can lead to environmental hazards. Therefore, integrated disease management using both bio-agents and fungicides is the best alternative. The results showed that Sclerotinia rot incidence in chickpeas was significantly reduced and yield increased when chemical and biocontrol agents were used together, compared to using either chemicals alone or biocontrol agents alone. Among the different treatments, the highest percent of disease control (81.40%) was found in T_{12}-Seed Treatment (ST) with tebuconazole 2% DS at 1.5 g/kg seed+Soil Application (SA) at 10 kg/ha with *Trichoderma harzianum*, followed by T_{11}-ST with tebuconazole 2% DS at 1.5 g/kg seed+SA at 10 kg/ha with *Trichoderma viride* (80.33%). The highest disease incidence was found in T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed (37.77%).

Key Words: *Biocontrol agents; Chickpea; Fungicides; Integrated disease management; Sclerotinia rot*

INTRODUCTION

Cicer arietinum, commonly known as chickpea, is an annual crop that grows in temperate and subtropical zones and is native to Southwest Asia. It is also called by various names such as gram, Bengal gram, garbanzo, garbanzo bean, Egyptian pea, chana and chole in various places. Pulses are the important source of protein in the diets of the poor and are particularly important in vegetarian diets. It is cultivated from ancient times both in Asia and European countries. India is the largest producer and consumer of chana in the world. India accounts approximately 75% of world's chickpea production. Mainly there are two types of varieties of gram desi and kabuli. Approximately 80% of the chana produced in world is of Desi type and the remaining is of kabuli variety. In India, Desi variety is also cultivated massively.

It is mainly consumed in the form of processed complete seed (boiled, roasted, fried, steamed, etc.), dal and as dal flour. It is used in preparing snacks, sweets and condiments. Fresh green seeds are also used as a green vegetable. It is an excellent source of protein (20.47%), carbohydrates (62.95%), fat (6.04%), minerals (calcium, phosphorus, iron etc.) and vitamins [1]. It is a superior animal feed and the straw of gram also have good or satisfactory forage value [2]. Due to the presence of malic and oxalic acid, the leaves of chickpea have sour taste. Malic and oxalic acids collected from green leaves of are prescribed for intestinal disorders. Chickpea is used as blood purifier and germinated seeds are recommended to cure scurvy disease.

Chickpea is cultivated in 25 states of India, Rajasthan is one of the major chickpea growing states of India after Madhya Pradesh and Maharashtra. In Rajasthan the major chickpea growing districts are Ajmer, Bikaner, Hanumangarh, Pali, Tonk, Bhilwara, Jaisalmer, Nagaur and Jaipur etc. In India, it occupies an area of 10 million hectares and its production is 11.91 million tons with an average productivity of 1192 kg ha-1. In Rajasthan, it is grown over 2.11 million hectares area with annual production and productivity of 2.27 million tons and 1072 kg ha-1, respectively. Unfortunately, the productivity of chickpea is not at the level of satisfaction i.e., average global productivity of 1800 kg ha-1 and it remains plateau since independence of India [3].

Nearly 172 pathogens (67 fungi, 22 viruses, 3 bacteria, 80 nematodes and phytoplasma) will cause diseases in chickpea [4]. These pathogens may be of bacteria, mycoplasma, fungi, nematodes and viruses which contain high genotypic variation. Among various biotic factors attributed to low productivity of chickpea, susceptibility to diseases is very important. Chickpea is susceptible to different diseases including, Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceri*), dry root rot (*Rhizoctonia bataticola*), wet root rot (*Rhizoctonia solani*), collar rot (*Sclerotium rolfsii*), Ascochyta blight and Sclerotinia rot (*Sclerotinia sclerotiorum* (Lib.) de Bary) [5]. These diseases have been found to cause considerable economic losses to the chickpea growers in India [6]. The extent of losses from 20% to 46% at pod bearing stage of the crop and the incidence of disease varied from 18% to 32% [7].

Amongst different diseases, Sclerotinia rot commonly called as stem rot or white mold caused by *Sclerotinia sclerotiorum* (Lib.) de Bary is one of the most important disease. The detonative pathogenicity under favorable conditions and the ability of producing sclerotia to withstand adverse conditions allow it to be a successful pathogen [8,9]. It causes significant yield losses whenever, the crop is grown in relatively cool and moist areas favorable for its development [7]. The disease causes total crop failure where chickpea is grown in the same paddock in successive years. Dense crops are likely to be the most severely affected, particularly, under moist condition. This disease has been reported from different parts of India and causing considerable losses [10]. The extent of the damage was reported from 21.3% to 46.7% at pod bearing stage of the crop [11]. In Jammu and Kashmir, the disease incidence varied from 18.7% to 32.2%. The recent observations suggested that the incidence and severity of Sclerotinia rot of chickpea is increasing in the Northern part of India. In Rajasthan, stem rot (*S. sclerotiorum*) was

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initially observed at Agricultural Research Station, Umedganj, Kota in the year 1993-1994 and thereafter, it has been appearing regularly in mild to severe form in various parts of the state [12].

MATERIALS AND METHODS

The fungicides are the most common tools for controlling plant disease. But they are not feasible for environment, health and it leads to environment hazard. Hence integrated management of the disease by using bio-agents and fungicides is the best alternative [13,14]. Therefore, it is an urgent need to use some bio-agents and fungicides which are effective against Sclerotinia rot disease. Hence, keeping in view the importance of chickpea crop and potential threat of *Sclerotinia sclerotiorum* in all the chickpea growing areas in the Rajasthan, the present investigation was undertaken to manage of this important disease through bio-agents and fungicides.

A field trial was conducted for the management of Sclerotinia rot of chickpea using bioagents and fungicides in rabi season. Talc based formulations of two fungal and two bacterial bioagent were applied as seed treatment and soil application and fungicides were used as seed treatment. Seed treatment of fungicides and seed and soil treatment of the talc based bioagent formulations was done. In case of control, seeds were sown in pathogen inoculated soil without any bioagents and fungicides. Observations were taken periodically for the disease incidence.

Total 13 treatments including control were carried out using randomized block design having plot size of 4 × 4 m2. Each treatment was replicated thrice. The experiment was conducted under artificial soil inoculated conditions. For this purpose, sand sorghum meal inoculum of *Sclerotinia sclerotiorum* was applied at 70 g per plot and mixed properly on top surface soil using a hand rack. Standard agronomic practices recommended for cultivation of chickpea crop in this region were followed. In case of control, the untreated seeds were sown. Observations on disease incidence were recorded periodically as well as the grain yield was recorded after harvesting of the crop.

Incidence of the disease and percent disease control was calculated by using the following formula [15];

$$Disease\,incidence\ (\%) = \frac{No.\ of\ diseased\ plants}{Total\ No.\ of\ plants\ germinated} \times 100$$

$$Disease\ control\ (\%) = \frac{Disease\ incidence\ in\ control\ (\%) - Disease\ incidence\ in\ treatment\ (\%)}{Disease\ incidence\ in\ control\ (\%)} \times 100$$

The data of percent disease incidence in all the experiments were transformed to their arc sin values [16]. The statistical analysis of the data of all the laboratory experiments was done following completely randomized design. The data of field experiments were analyzed following randomized block design.

RESULTS AND DISCUSSION

The results in Tables 1 and 2, show that Sclerotinia rot incidence in chickpeas was significantly reduced and yield increased when chemical and biocontrol agents were used together, compared to using either chemicals alone or biocontrol agents alone. Among the different treatments, the highest percent of disease control (81.40%) was found in T_{12}-seed treatment with tebuconazole 2% DS at 1.5 g/kg seed+soil application at 10 kg/ha with *Trichoderma harzianum* followed by T_{11}-ST with tebuconazole 2% DS at 1.5 g/kg seed+SA at 10 kg/ha with *Trichoderma viride* (80.33%), T_{10}-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed+SA at 10 kg/ha with *Trichoderma harzianum* (78.89%) and T_9-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed+SA at 10 kg/ha with *Trichoderma viride* (77.45%) as compared to control where 62.37 percent disease incidence was recorded. The highest disease incidence was found in T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed (37.77%), followed by T_4-ST at 10 g/kg+SA at 10 kg/ha with *Bacillus subtilis* (34.67%) and T_3-ST at 10 g/kg+SA at 10 kg/ha with *Pseudomonas fluorescens* (32.50%). The results revealed that all twelve treatments, including single fungicides and their combinations with biocontrol agents, were superior to the control in reducing disease incidence and increasing seed yield of chickpea (Figure 1).

TABLE 1

Management of Sclerotinia rot of chickpea by bioagents and fungicides

Treatments	Disease incidence (%)*	Disease control (%)
T_1-ST at 10 g/kg+SA at 10 kg/ha with *T. viride*	21.33 (27.42)	65.79
T_2-ST at 10 g/kg+SA at 10 kg/ha with *T. harzianum*	20.27 (26.70)	67.5
T_3-ST at 10 g/kg+SA at 10 kg/ha with *P. fluroescens*	32.50 (34.73)	47.89
T_4-ST at 10 g/kg+SA at 10 kg/ha with *B. subtilis*	34.67 (36.04)	44.41
T_5-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed	26.37 (30.87)	57.72
T_6-ST with tebuconazole 2% DS at 1.5 g/kg seed	24.23 (29.46)	61.14
T_7-ST with tebuconazole 50%+trifloxystrobin 25% WG at 1.5 g/kg seed	27.73 (31.74)	55.53
T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed	37.77 (37.89)	39.44
T_9-T_5+SA at 10 kg/ha with *T. viride*	14.07 (21.98)	77.45
T_{10}-T_5+SA at 10 kg/ha with *T. harzianum*	13.17 (21.23)	78.89
T_{11}-T_6+SA at 10 kg/ha with *T. viride*	12.27 (20.46)	80.33
T_{12}-T_6+SA at 10 kg/ha with *T. harzianum*	11.60 (19.79)	81.4
Control	62.37 (52.15)	0
S.Em±	1.66	67.00%
CD at 0.05	4.87	67.00%
CV (%)	11.04	67.00%

Note: ST: Seed Treatment; SA: Soil Application; WP: Wettable Powder; WG: Water-Dispersible Granule; DS: Dustable Sulfur; S.Em: Standard Error of the mean; CD: Critical Difference; CV: Coefficient of Variation.

TABLE 2

Effect of bioagents and fungicides on the yield of chickpea

Treatments	Yield (q ha-1)*	Yield increase over control (%)
T_1-ST at 10g/kg+SA at 10 kg/ha with *T. viride*	12.03 (20.22)	124.22
T_2-ST at 10g/kg+SA at 10 kg/ha with *T. harzianum*	12.83 (20.93)	139.13
T_3-ST at 10g/kg+SA at 10 kg/ha with *P. fluroescens*	8.90 (17.25)	65.84
T_4-ST at 10g/kg+SA at 10 kg/ha with *B. subtilis*	7.93 (16.16)	47.83

T_5-ST with carbendazim 12%+mancozeb 63% WP at 2 g/kg seed	10.43 (18.69)	94.41
T_6-ST with tebuconazole 2% DS at 1.5 g/kg seed	11.17 (19.41)	108.07
T_7-ST with tebuconazole 50%+trifloxystrobin 25% WG at 1.5 g/kg seed	9.70 (18.03)	80.75
T_8-ST with thiophanate methyl 70% WP at 2 g/kg seed	7.13 (15.33)	32.92
T_9-T_5+SA at 10 kg/ha with *T. viride*	14.47 (22.28)	169.57
T_{10}-T_5+SA at 10 kg/ha with *T. harzianum*	15.37 (23.01)	186.34
T_{11}-T_6+SA at 10 kg/ha with *T. viride*	16.07 (23.57)	199.38
T_{12}-T_6+SA at 10 kg/ha with *T. harzianum*	16.90 (24.20)	214.91
Control	5.37 (13.14)	0
S.Em±	1.24	CV (%)
CD at 0.05	3.65	CV (%)
CV (%)	11.11	CV (%)

Note: ST: Seed Treatment; SA: Soil Application; WP: Wettable Powder; WG: Water-Dispersible Granule; DS: Dustable Sulfur; S.Em: Standard Error of the mean; CD: Critical Difference; CV: Coefficient of Variation.

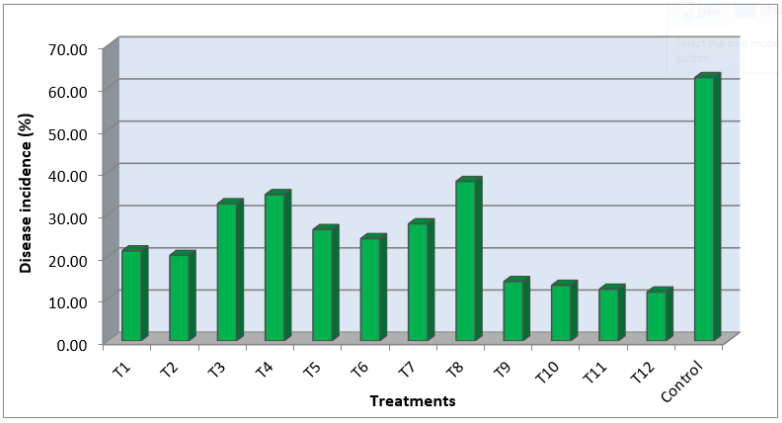


Figure 1) *Effect of bioagents and fungicides on Sclerotinia rot disease incidence of chickpea*

Similarly, Pandey et al., found that applying vermicompost at 5.0 tons/ha combined with *T. harzianum* at 5.0 kg/ha was the most effective treatment, reducing disease incidence by 72.73% and increasing grain yield by 39.69% [17]. This was followed by Farmyard Manure (FYM) at 2.5 tons/ha combined with *T. harzianum* at 5.0 kg/ha, which resulted in a 64.85% reduction in disease incidence and a 38.17% increase in grain yield. The least reduction in disease incidence (14.55%) and the smallest increase in grain yield (15.27%) were observed with foliar spray of P. fluorescens at 5.0 g/liter. Mandal et al., reported that seed treatment with Pusa 5SD (*T. viride*) combined with carboxin and *Mesorhizobium ciceri*, along with a foliar spray of iprodion 40 days after sowing, provided the highest disease reduction and improved plant health parameters such as seed germination, shoot and root lengths and the number of pods per plant [10]. While Pusa Biopellet 4G and Pusa 5SD individually were effective in reducing disease incidence and enhancing plant health, their combined application was superior to using any of these formulations alone. Sharma et al., evaluated six different fungicides against *S. sclerotiorum* under *in vitro* conditions and tested their efficacy in controlling Sclerotinia rot in pot conditions [18-20]. Carbendazim and the consortium formulation of carbendazim 12%+mancozeb 63% were significantly superior to the other fungicides in inhibiting the mycelial growth of the pathogen and controlling Sclerotinia rot, achieving 100% growth inhibition at a lower concentration (50 ppm) and 73.94% and 67.57% control of rot incidence when applied as a seed treatment (2 g/kg) and foliar spray (0.1% and 0.2% solution), respectively. Propiconazole was the next most effective, providing 67.41% inhibition of growth at the lowest concentration (50 ppm) and 61.21% protection against rot incidence when applied as a seed treatment (2 ml/kg) and foliar spray (0.1%).

CONCLUSION

Chickpea is an annual legume crop legume crop cultivated in temperate and subtropical regions. It is a member of the Fabaceae family. Among various diseases, Sclerotinia rot, also known as stem rot or white mold, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, is one of the most significant. This disease is highly pathogenic under favorable conditions and produces sclerotia that can endure adverse conditions, making it a highly successful pathogen. It causes substantial yield losses, especially in cool and moist areas conducive to its development. The fungus's explosive pathogenicity and the resilience of its sclerotia contribute to its success as a pathogen. Due to its strict soil-borne nature and wide host range, managing this disease through host resistance or chemical management alone is challenging. Fungicides are commonly used to control plant diseases, but they pose environmental and health risks and can lead to environmental hazards. Therefore, integrated disease management using both bio-agents and fungicides is the best alternative.

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REVIEW ARTICLE

The integration of Internet of Things (IoT) in precision agriculture

Zaiba Khan*

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Precision Agriculture (PA) is a type of agricultural technology that is widely used in the field of agriculture. The Internet of Things (IoT) is one of the most widely used technologies for precision agriculture. However, the application of IoT in precision agriculture has not been fully explored. In this article, a comprehensive review of the current innovative means of utilizing the internet of things in PA practices was carried out. The paper provides a concise review of current applications of the internet and communication technologies in PA. In addition, the paper discusses the design architecture of communicating systems and communication system technologies. The results of the carried-out technical review are as follows: (a) A detailed study of the features of the utilized sensors, agricultural fields and crop changes and the design of communication systems are the key outcomes of the technical review; (b) Using big data for IoT applications in precision farming allows the aggregation and management of a large volume of data captured from a wide variety of different sources; (c) The effective use of big data can have broad and potentially transformative effects for making progress in how to apply IoT for precision agricultural; (d) The current state of the art of integrating Internet of Things (IoT) with precision agriculture is mainly based on the concept of the web of things.

Key Words: *Internet of things; Precision agriculture, Communication system; Web of things*

INTRODUCTION

The integration of the IoT with current applications and future technologies has a noteworthy impact on the economy, society and environment. Consequently, IoT is increasingly found in various sectors and domains, agricultural production being one of its beneficiaries. The current flow of research and development, investment opportunities and the rapid growth of the market highlight the overall potential of smart agricultural solutions. The paper provides a concise review of the current applications of IoT in precision agriculture. We further provide readers with different use case scenarios by describing each step of the research pipeline in precision agriculture, such as monitoring and control including cloud computing, alert systems and other web-based artifacts. We conclude that the IoT has already provided valuable conclusions in the field by performing intelligent data analysis of greenhouses with vertical farming and aeroponics. In the near future, we expect each farmer to take advantage of IoT technology by using some of the agricultural platforms available by connecting their traditional tools and microservices [1,2].

In the field of precision agriculture, the role of scientists and researchers is to increase yield and agricultural management using their knowledge in the field of electronics, software and sensors. PA is an overall term for site-specific crop management, which includes making the right crop input at the right place and the right time, taking into consideration individual field and crop conditions. With a proactive stance to modifying practices to best meet the crop requirements using the available resources and not necessarily maximizing yields, PA contributes to sustainable agricultural development. The design, development and integration of new technologies uniquely customized to the specific conditions of agricultural production make PA a dynamic, interdisciplinary field that uniquely combines biophysical and socioeconomic concepts and methodologies. In present-day agricultural practices, the IoT concept is widely used to achieve a more modern and effective agriculture [3,4].

LITERATURE REVIEW

IoT technologies in precision agriculture

Sensors, networks, Unmanned Aerial Vehicles (UAV), tractors and other smart machines are considered to be the most important elements of the IoT technology-assisted smart farming process. The IoT in smart farming feature of the novel agricultural approach aims for eco-friendly, profitable, productive and well-timed harvests automatically. In this way, it helps the hardware, software and Information Technology (IT) engineering teams as well as farming engineers and agricultural experts to frame smart farming techniques. They also would like to accomplish their smart systems by exploiting their machinery, media server and cloud to monitor farm regions automatically [5,6].

In the agriculture sector, there is a growing demand for the use of technology to enhance production, reduce labor, efficiently utilize resources and decrease adverse environmental impacts. There are several technology solutions deployed for solving agriculture-specific technical problems. A blend of agriculture and technology makes farming smart or intelligent and it is termed as precision agriculture. Precision agriculture involves the use of extensive data about weather, farm conditions and other variables, data acquisition tools, IoT and Artificial Intelligence (AI) software to process this data to monitor and manage crop growth. The goal of precision agriculture research is to define a Decision Support System (DSS) for the entire farm management process so as to optimize returns on inputs while taking into consideration environmental, economic and social sustainability. The integrated use of several smart gadgets and technologies like sensors and actuators, GPS, robotics, AI and IoT with the drones make the system intelligent. The IoT-based setup for precision agriculture is called smart farming [7].

Sensors and actuators: Sensors and actuators are the core of precision farming as the whole idea is based on measurements and management of field variability. There are three main types of sensors applied in precision farming: crop sensors, soil sensors and weather sensors. Crop sensors are utilized for measuring the color and reflectance of leaf vegetation. On the other hand, soil sensors are used for the measurement of soil properties, such as the content of moisture, temperature, texture and salinity. Conversely, weather sensors provide the measurement of environmental data. Additionally, actuators also have a key role in precision farming as they are being used for precision seeding, irrigation and fertilization [8].

Wireless communication technologies: Simple gateway and sensors facilitate load balancing across the system and energy management to extend class battery life. Moreover, this platform is supported with existing cellular infrastructure. It is a national network operator for public-based IoT to provide connection services for IoT devices nationwide. There are various types of Low Power Wide Area Network (LPWAN) technology. They use distinct

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connectivity, bandwidth type, range, service and data transport quality. The diagram offers a low-power long-range communications solution to extend and simplify wireless connectivity for smart cities, smart agriculture and other remote monitoring systems. Sub-1 GHz design centers are attracting great interest. The standard argues to reduce development barriers for suppliers of system-on-chip sensors and gateways, resulting in high compatibility and an extensive selection of diverse communication-informative interest. The performance of traditional sub-1 GHz systems excels in link budget and data rates. However, the excessive link budget is a deterrent because it consumes more power and supports a very short range. The long-range and low-power requirements for IoT devices make these constraints very different. Wireless intelligent networks for sliding window scenarios are used to improve system performance while avoiding overlapping transactions from multiple devices. These are fundamental in large aggregation applications, such as asset tracking, street lighting and condition monitoring [9].

The communication with the devices is more challenging. The devices related to the IoT may involve terrestrial, satellite or hybrid systems. Unlike terrestrial systems, satellite communication can provide resources for a long-range, one-to-many communication model, customized for sparse and remote locations. However, the propagation delay is a key concern for terrestrial devices which require timely interaction such as monitoring and controlling. Many of the supporting technologies and system tools have been progressing over years. Thus, development related to the IoT is inclined with evolution rather than creation. One of the requirements for telemetry in rural and outdoor environments is long-range communications. This kind of communication offers some advantages in different practical activities. LPWAN is a type of wireless network designed for long-range communication with small data streams required by IoT devices.

Data collection and analysis in precision agriculture

The term "actual" refers not only to the timing but also to the precision of the information produced and to the decision support criteria adopted by the decision makers. The online monitoring and the offline data mining are mechanisms strongly linked to each other, which have to be integrated into the information system to provide demonstrations of the current and future state and related research, along with detailed explanations on significant trends. This information is organized in the shape of an active map, providing the evaluated and foreseen status of an activity before during and after the occurrence at different resolution scales.

Precision agriculture is divided into three management levels. Management level 1 deals with the activities aiming to describe the state of the cultivated plants or observed characteristics of samples. All relevant characteristics or parameters describing the physical condition are collected and can then be used to verify the supposed plant behavior according to the models or reference conditions. This data can be exploited by real-time centers, which adjust any actions, e.g. operating parameters for the agricultural machines, fertilizers and plant protective agents to the actual requirements and therefore optimize the process. They are designed to evaluate an actual situation but also the future development of a given activity, irrespective of it being related to the control of machines and procedures or to the forecast of plant and animal conditions at different scales.

Remote sensing technologies: Trimble GreenSeeker is a passive sensor that provides real-time yield estimates. The optical sensor is suspended directly over the row crop to be monitored. Light output is used to determine uniformity for a single row, and crop density is recorded in overall uniformity. The Global Positioning System (GPS) signal is used to determine the speed of travel while the sensor is activated. Data is computed and displayed in a map chart with the GPS data. The GreenSeeker operates down to three inches above the canopy of row crops such as cotton, corn, sugarcane and wheat. Grazing research has used a GreenSeeker monitor to establish and compare the overall relative forage quantity of grazed and ungrazed ranges.

CropScan is a passive crop-infrared sensor that measures the amount of light reflected by the leaves, then converts it to a Leaf Area Index (LAI) measurement. The LAI measurements can be used to control ripening and check the overall plant health. The reflectance-based measurements are obtained in the near-infrared and visible spectrums. CropCircle is also a passive sensor tool that can calculate the leaf area index of a crop stand. It measures red and near-infrared reflectance at four spectral bands to derive the LAI measurements [10].

Remote sensing technologies have an important role in precision agriculture as they direct the use of resources according to the variability in the field. The images, taken by sensors, show the spatial variability of the factors affecting crop yield and give farmers the necessary spatial information for decision-making. It is a low-cost solution to provide timely status. There are two types of remote sensing: Passive sensors and active sensors. Passive sensors measure the solar radiation reflected or emitted by objects.

Big data analytics: The whole basis for IoT is to connect everyday devices to a network with the ability to send and receive data. Most people are considering mundane things like watches, washing machines, dishwashers and the like but the same hypothesis can also be applied to fields of crops, irrigation equipment, soil nutrients, weather, crop pests, crop diseases and humidity. Furthermore, interconnections can also be made to crop forecasting, transportation, weather forecasting, energy usage, mobile operations and many others. This is where the connected environment is going. Smart agricultural industries embedded software into the controllers that do everything from monitor soil weight to provide the perfect environment for root growth and associated needs. This is picture recognition and logistics of the highest level.

This refers to large amounts of data from precision agriculture, which can come from various sources such as satellites, GPS and mapping systems, sensors and telematics, environmental factors such as weather forecasts or historical weather data and wide expertise from service/equipment providers, growers, toxicologists, entomologists and plant pathologists etc. Often, data is multilayered and can be very complex. Big data analytics are crucial to this topic mainly in the following areas of scientific research for generating new ideas, knowledge discovery, finding innovative patterns and building decision support systems. Crop modelling decision support, pest management, decision support, decision support for irrigation and soil management, yield variability and decision support have all taken or are taking advantage of big data for forwarding enhanced solutions.

IoT applications in crop monitoring and management

One of the principal areas that can leverage the use of IoT is precision agriculture. Precision agriculture is an agro-industrial management model where producers can identify in the field, monitor and apply crop inputs in real time for improved productivity. Among the products that this technology can supply are reduced use of chemical inputs such as pesticides, improved control over irrigation applied to land and greenhouse products, soil evaluation with consequent application of nutrients, reduction of physical damage in post-harvest, higher productivity and improved early prediction of crop productions, which optimizes logistics of storage and transport. The benefits of implementing precision agriculture for producers can include improving the quantity and consistency of products, optimizing the application of inputs, reducing environmental impact, respecting the existing legislation and thus mitigating risks, making economic and efficient decisions [7,11].

By generating pertinent agricultural information from a variety of resources (sensors, drones, satellites, georeferenced reports, among others) within a complex and dynamic reality, data analysis can be simplified. Moreover, the possible interactions of this collected data can contribute to agricultural control and management by reducing the ecological and economic threats on crop production. Advances in information and communication technologies have contributed strongly to the creation of the term Internet of Things (IoT), a set of physical objects that can exchange information and messages *via* the internet. The IoT is portrayed by systems connecting devices and objects that are uniquely identifiable on the network.

Soil moisture monitoring: There is a library of countless papers detailing the great number of soil moisture measuring devices enhancing precision agriculture. The importance of this figure lies in the fields in the research area, showing that engineers have to pay much more attention to R4, i.e., correct device utilization. The amount of water in the soil is presented in a large range, besides technological area better than a half a century available for artificial (irrigation) support to the plants. The amount of water determines the chemical and biological reactions as well. Large portions of the Earth are semi-arid or arid lands and areas with scarcity of water belonging to 70% of the world's population are widespread. These two key figures highlight the fact that the importance and the attention of managing water does not stop at the "normal" agricultural lands but should be definitely and attentively

considered in large areas of the World. On the other hand, in humidity areas, water might be toxic as well if present in very high excess. Satisfying the requirements of the plants is not a simple task at all.

We detailed the importance of soil moisture to the crop and how it is traditionally and in modern agriculture monitored. Then, we discussed the technology choices of soil monitoring in precision agriculture in the light of soil's electrical characteristics using five different future scenarios for in-field soil moisture monitoring. The great importance of soil moisture for plants is widely known. Soil moisture, described in percentage or volume units and measured by the volumetric is the most critical environmental parameter for most plant species. The plant itself causes several processes within the plant for example, photosynthesis and nutrient transportation. If it is not present at the distance required by the crop, one of the immobile nutrients can become limiting. Plants have no possibility of getting the needed moisture. The closeness of the water within the plant fluctuating around 95%. Due to rapid moisture loss, plants can collapse in a very short period under unfavorable, for example, dry and hot, conditions [11].

Pest and disease detection: Currently, pest and disease detection is primarily based on the scouting methodology, where trained agricultural personnel move throughout the plants, visually checking for diseases and pests at a set frequency, depth and method. This traditional physical methodology creates problems such as high work costs, pathogen transmission between plants or other fields, inaccuracy, inconsistency and delay in detection. In line with this, biological methods have been developed, based on the deployment of beneficial insects on a set frequency, but their success is highly dependent on the density and type of beneficial insects in the field. Early detection is the key in both cases. This is the focus of hypsometric plant sensing. However, there are a few pests and diseases for which remote sensing is difficult, such as the apple maggot. In line with that, pest modeling includes pest life stage models, which use biological sub-models that predict the stage of the pest based on initial pest life-stage inputs. Typically, the proximal inputs to these models are thermal sums, measured in degree days based on daily mean temperatures in the environment. More recently, these pest models have been applied in IoT-based precision agriculture systems to assist farmers in deciding which time is most opportune to apply commercial pheromones and matrics, e.g. the entomopathogenic fungus *Metarhizium brunneum*, in the case of *Drosophila suzukii* pest control [12,13].

Pest and disease detection is one of the categories with the highest potential benefits of the implementation of internet of things sensors in precision agriculture. This category is highly relevant for the European Union (EU), where the reduction in the quantity of Crop Protection Agents (CPAs) as well as the partial replacement of existing CPAs are important issues and are defended in the 2020 European Green Deal. Pest and disease detection is directly related to reducing the use of CPAs, by automatically detecting the first stages and triggering the deployment of beneficial insects or other methods for controlling these issues without using CPAs. In addition, rapid and automatic detection is also related to early disease or pest control with CPAs, which normally requires resolved symptoms.

IoT applications in livestock monitoring

In the last few years, many studies have shown that the precision of animal production can be improved by the use of IoT technologies. The main argument in livestock management is to bring the right tools for support in critical decisions regarding farm management in all areas, enabling animals to express their maximum genetic potential, ensuring animal welfare and increasing the sustainability of the production system. By monitoring animals individually (e.g. feeding, reproduction and health), an increase in efficiency of farms is expected. The requests for products derived from livestock are increasingly specific, so precision supplementation is indispensable. The forage availability measurement is also significant for ranchers who carry out rotational management. Within this branch of IoT, there is a technological trend that uses "sensors to talk to plants". Water is also an important factor to consider in the management of livestock. Scientists have defined different ways to monitor water stress. In addition, it is necessary to reinforce that excessive water supply is as dangerous as insufficiency. Dairy cows and bulls remember the seasonal quality of food, so the availability of grass throughout the year must be guaranteed.

DISCUSSION

Challenges and opportunities in implementing IoT in precision agriculture

It is important for professional scientists to integrate a large number of things in precision agriculture to shape our future of smart farming. In an engineering point of view, this means establishing highly integrated and intelligent communication and sensory systems in agricultural fields, to achieve more focused and quantitative data than human-based observations. The proliferation of precision agriculture brings together the concept of the Internet of Things (IoT) and agriculture, specifically for information delivery, analysis and support for precision agriculture technologies. The technical research costs for most agricultural studies related to IoT also seldomly meet the sophisticated demands of agricultural researchers. The opinions of how IoT may contribute to precision agriculture also vary. Important scientific challenges arise from combining different types of sensory data over time and using it to provide advice to a farmer in an operational setting. The first question that should be asked in this context is what is the environment, specifically agriculture, that an IoT for agglomerating various sensing items involves. This question requires more than a look at the enabling technologies.

Precision agriculture requires the acquisition of data with various sensing technologies. To fulfill the need for more specific data, the number of sensors is extended through the principles of IoT to form Internet of Things specific to Agriculture (IoTA). In this article, a detailed review of current state-of-the-art means of utilizing IoT in PA practices was carried out. An investigation into the features of the utilized sensors, agricultural fields and crop changes, the design architecture of communicating systems and communication system technologies are the key outcomes of the carried-out technical review. Although those are not all that is needed to integrate IoT in PA practices, eight steps, in the format of a flowchart, were developed to guide professional scientists working on implementing IoT in PA practices. According to the carried-out review, these steps should be tailored considering PA demands and the available resources. The identification of not only the communication systems encompassing IoT sensors, but also transmitting transmitted data, is required for PA applications to be improved.

Data security and privacy concerns: In large-scale precision agriculture practices, several agricultural sensors need to be cascaded and deployed on farmland and these sensors can communicate wirelessly to form the edge network of a large-scale precision agriculture internet of things system with agricultural production equipment for field *in-situ* monitoring and the collected data is transmitted to the decision-support expert agricultural management system through base stations or gateways. The IoT system aggregates the rich, real-time data of the remote planning and execution processes in the extended edge network and connects service procedures for direct or indirect interoperability *via* a back-end service procedure bus to support high-level decision making, high-quality mission operation and personalized, proactive agricultural management.

In agricultural practice, a variety of new technologies have been a breakthrough and the application of precision agriculture has achieved remarkable results. The continuous evolution of the IoT has also made our lives full of wisdom, but during the integration of the internet of things in the application of precision agriculture, we also need to pay attention to data security and privacy protection. This paper mainly integrates low-latency, low-power and low-cost wireless communication technology for energy-constrained devices such as sensors and actuators. We build long-range, large-scale IoT systems to meet the needs of large-scale data collection and data interactions in precision agriculture.

Interoperability issues: The intertwining of ubiquity, intelligence and connectivity, which are enabled by wireless sensor networks, embedded systems and Internet technologies, is the key point to create the IoT. Effectively, small-scale households or individuals can build sensor networks to enable the connection to everyday objects. However, most sensor nodes are involved in sensor network activities to achieve a specific goal, without sharing their sensing data with other users. The services to be developed are strictly dependent on the sensors and their locations, which in culturally different locations, population densities and pacing, leads to services that waste infrastructure, power and invaluable time. It is, in fact, a complicating

IoT issue. Interoperability in the IoT context means enabling the interaction and cooperation of heterogeneous devices and services in a transparent or invisible way, in such a manner that the user is unaware of their presence. It is a key concept for creating an open working environment for devices and services in the IoT, allowing the development of advanced applications with new and rich functionalities previously unimagined. In particular, interoperability issues of IoT devices employed in precision agriculture can be identified as either technological myths about IoT being solved or current problems-situations that are real, but the technology is currently dealing with.

Future trends and innovations in IoT for precision agriculture

Using big data applications in IoT-assisted precision agriculture allows the aggregation and management of a large volume of data types captured from a wide variety of different sources. The effective use of big data for IoT applications in precision agriculture will involve improvements in information technology and communication technology to manage the capture and sharing at appropriate spatial granularity, cost and scale. Appropriately structured data sets can guide smart data analytics to provide direction and decision assistance for its sensor informatics users. Common access to these data can also have economic benefits, such as better risk-based pricing that insurance companies can apply to provide their growing market for agricultural weather insurance. The effective use of big data can have broad and potentially transformative effects for making progress in how to apply IoT in precision agriculture. Smart data capture and sharing can enable savings over the entire food production and processing chain. The early identification of supply and demand imbalances can enable price smoothing over regular and irregular fluctuations in market conditions. In the long run, participants in the food production and processing chain can benefit from forward contracts that reduce the risk for their primary product pricing changes under volatile market conditions [14,15].

Future direction of IoT for precision agriculture involves adapting IoT for precision agriculture, using big data to guide IoT applications and adopting interlinked governance for resolving concerns raised with the implementation of IoT for precision agriculture. Agriculturists are the most affected stakeholders by the adoption and use of IoT for precision agriculture applications. They are also the ones who use and generate the data that enable the development of related applications. To achieve integration and formulation with IoT applications and precision agriculture has the potential to change the consumer-to-farmer relationship in a way that places agricultural producers at the center of an agri-food innovation system. This will require improved information flow and coordination, establishing a feedback loop [16].

CONCLUSION

In conclusion, the integration of internet of things with precision agriculture is transforming agricultural practices by enhancing data collection and analysis, leading to more efficient and sustainable farming. The review highlights how IoT technologies, including sensors and big data analytics are instrumental in optimizing crop and livestock management, improving resource use and reducing environmental impact. Despite advancements, challenges such as data security, interoperability and the need for effective communication systems remain. Future innovations are expected to refine these technologies further, making precision agriculture more accessible and impactful. Ultimately, internet of things role in precision agriculture promises significant improvements in agricultural productivity and sustainability.

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REVIEW ARTICLE

Green revolution-based perspectives on information technology utilization for sustainable agricultural development

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Pareek S. Green revolution-based perspectives on information technology utilization for sustainable agricultural development. AGBIR.2024;40(5):1322-1325.

Horticultural techniques and advancements are diverse due to the inherent differences among plant species, each with unique needs and growing conditions. This diversity drives the development of specialized methods customized to various plants. Progress in horticulture is greatly enhanced by the global exchange of knowledge among horticulturists, researchers and farmers. As information about effective techniques and innovations is shared across borders, it leads to improved practices and solutions. Technology has become an important platform for facilitating this global communication, transforming how horticultural information is disseminated and applied. This interconnectedness enables practitioners to adopt and adapt successful methods from different regions, significantly advancing the agricultural sector. The result is a more efficient and sustainable approach to horticulture, benefiting everyone involved from farmers who achieve better yields to consumers who enjoy higher quality produce. Ultimately, this global collaboration and technological integration encourage continuous improvement and innovation in horticulture.

Key Words: *e-Choupal; Information technology; Digital technology; Agricultural*

INTRODUCTION

Farming in India is the center division for sustenance security, wholesome security and feasible advancement and for neediness mitigation. It contributes approx 18% of Gross Domestic Product (GDP). Achievements in agribusiness advancement in India incorporates: Green insurgency, evergreen upset, blue transformation, white unrest, yellow unrest, bio innovation unrest and the latest one is information and correspondence innovation revolution [1].

Information Technology (IT) supports new techniques for accuracy horticulture like automated ranch hardware that applies for composts and pesticides. Ranch creatures are encouraged and checked by electronic sensors and recognizable proof frameworks. Offering or purchasing on the web started to wind up prominent on the planet. In any case, it's most imperative job remains correspondence and the internet has given us a perfect chance to do as such.

State governments and private associations have taken IT gauges for farming expansion which incorporate ITC-e-choupal, Kisan Kerala, Aaqua, rice information the board gateway, e-krishi, Mahindra Kisan Mitra, Indian Farmers Fertiliser Cooperative Limited (IFFCO) Agri-entryway, Village Knowledge Centres (VKCs) associated with the M.S. Swaminathan Research Foundation (MSSRF), these centers provide localized agricultural information and training to farmers and Village Resource Centres (VRCs) run by the Indian Space Research Organization (ISRO), these centers use satellite technology to support rural development, including agriculture, by providing information on weather, soil conditions and crop management. [2].

LITERATURE REVIEW

Changing rural India with the help of digital technologies

IT is turning into the facilitator of financial advancement in country India with its undeniable offices by method for wellbeing, instruction, monetary administrations and work paths and so on. It can help the extension problems by giving electronic (e) and mobile (m) administrations. IT offering implied for rustic area can be grouped into three classes:

1. Those arrangements which point are gone for strengthening.
2. Those which would do enablement.
3. Those for market development.

This is case of proficient production network framework engaging the agriculturists with appropriate and important data empowering them to show signs of improvement returns for them to create. Because of its location-driven methodology, it gives different contributions additionally to the agriculturists resembles protection and homestead the executives practice and so on.

The act of e-administration, which makes straightforwardness and administration through IT, has empowered the nationals. Fruitful usage of e-administration in the zones like-keep up land records is an incredible advance in evacuating the acts of neglect and making confirmation of legitimate proprietorship.

Aadhar is another such application, which has enabled the majority by affirming their characters and is genuine case of IT arrangement endeavoring to give access to money related advantages by setting up the right personality and along these lines rustic economy is likewise growing. Market development with its assistance can be seen through different models for example, as of late the town and legacy the travel industry in remote territories of the nation has gotten an immense force and this has been done by virtue of mindfulness being made by the online entrances, pulling in more users contrasted with past.

Coordinate associate through web-based business has encouraged expansive number of craftsman's agro-based little undertakings in provincial territories. Ladies occupation is being encouraged among the weaver's locale in the north eastern states by showcasing their item through the web medium. Indian rustic market is running under change with better access to data. With its assistance, agriculturists can utilize the administrations of Fertilizer and Marketing Cooperative (FMC) and can show signs of improvement esteem for their item. As we probably are aware advancement is a procedure which takes couple of years to change the country life. In this way data innovation will be in a situation to change the situation of provincial life and make a superior way for rustic advancement.

Among the states, Maharashtra was on top with the 104 out of 1,000 families had internet in urban areas, trailed by Kerala and Himachal Pradesh at 95 each and Haryana at 81.5 [3].

Information technology and agriculture

Cultivating and Information Technology (IT) by all accounts the most indirectly set learning sets on the planet. Cultivating being the crudest and most fundamental of the employments and IT related being the most developed and generally present day.

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However, we know the significance of cultivating as it is basic forever support on the outside of environment and it is essential for the improvements in IT to help for the advancement of cultivating to deliver better.

The data identified with approaches and projects of government, plans for ranchers, establishments through which these plans are executed, new advancements in agribusiness, Good Agricultural Practices (GAPs), institutions giving new horticultural inputs (high yielding seeds, new manures and so on) and preparing in new methods are dispersed to ranchers through utilization of Information innovation to guarantee comprehensiveness and to maintain a strategic distance from computerized division [4].

Access to cost data access to horticulture data access to national and global markets, expanding generation proficiency and making a 'helpful arrangement condition' are the gainful results of e-agriculture which upgrade personal satisfaction of ranchers.

Soil management, water management, seed management, fertilizer management, pest management, harvest management and post-harvest management are the essential parts of e-agriculture where innovation helps ranchers with better data and choices. It utilizes a large group of advancements like remote sensing, computer simulation and assessment speed and heading of wind, soil quality tests in India, there have been a few activities by State and Central governments to address the different difficulties affecting the horticulture area in the nation.

The e-agriculture is a mission mode project, which has been incorporated into National e-Governance Plan (NeGP) with an end goal to unite the different learnings from the past, coordinate all the assorted and unique endeavors as of now in progress and upscale them to cover the whole nation.

The Mission Mode Project (MMP) is to be operationalized by Department of Agriculture and Cooperation (DAC) and expects to give administrations, for example:

1. Information to agriculturists on seeds, composts, pesticides.
2. Information to agriculturists on government plans.
3. Information to agriculturists on soil proposals.
4. Information on harvest the executives.
5. Information on climate and advertising of agribusiness deliver.
6. Government ventures to give e-help to agriculturists.

National mission on agricultural extension and technology

The point of the mission is to rebuild and reinforce rural augmentation to empower conveyance of proper innovation and enhanced agronomic practices to ranchers. This is visualized to be accomplished by a wise blend of broad physical effort and practical techniques for data distribution, utilization of IT, advancement of present day and suitable advances, limit building and organization reinforcing to advance automation, accessibility of value seeds, plant assurance and other resources, as well as Farmers into Interest Groups (FIGs) to frame Farmer Producer Organizations (FPOs) [1].

Universal Service Obligation Fund (USOF) as of now propelled remote broadband scheme in 2009. USOF is additionally financing the National Optical Fiber Network (NOFN), which is being overseen by Bharat Broadband Network Limited. Transmission capacity from NOFN will be qualified to give wide scope of administrations to country India [5].

Pilot venture plot for mobile Value-Added Services (m-VAS) for country ladies Self-Help Group (SHG) is additionally part of USOF's Sanchar Shakti program. In this the SHG based on their exercises are furnished with data in nearby dialects through Short Message Service (SMS), Outbound Dialing (OBDs) and Integrated Voice Response System (IVRS) [6].

Bharat Nirman Kendra, will be a solitary window for giving the data on the National Rural Employment Guarantee Scheme (NREGS) and will give input on the nature of usage of the program. The thought is to gradually proceed onward the wage work to independent work by giving ability improvement offices to the provincial individuals and in the process gives a fillip to the country economy. In future it can likewise wind up place for e-empowered examination or e-learning focus [1].

For cultivate credit, administration of IT is being saddled like smart cards, internet kiosks and mobile phone informing. And furthermore, payment of all government disability benefits through electronic advantage exchange to every provincial zone. Versatile empowered kisan card framework to enable the rural network to take part in cashless exchanges.

Kisan credit card: It utilizes the IT to give reasonable credit to ranchers in India. It was begun by the government of India, Reserve Bank of India (RBI) and National Bank for Agriculture and Rural Development (NABARD) in 1998-1999 to enable ranchers to get to opportune and sufficient credit.

The Kisan credit card enables agriculturists to have money credit offices without experiencing tedious bank credit screening forms more than once. Reimbursement can be rescheduled if there is an awful harvest season and expansions are offered for up to four years. The card is legitimate for a long time and subject to yearly recharges. Withdrawals are made utilizing slips, cards and a passbook [2].

Kisan choupal in a joint effort with Krishi Vigyan Kendra is an effective model in Bihar. It is being led in recognized town based on need evaluation of the ranchers by the researchers on farming and united endeavors.

At Kisan chouapl, the discourse, talk, issues illuminating is encouraged with help of information advancements, demonstrating specialized recordings to agriculturists, films and so forth toward the start of the choupal. This has expanded the attention to ranchers on reducing rehearses and new procedures. This has additionally encouraged better and more extensive reach of the advances in the agriculturist network.

Kisan call focus: A specialist warning framework and the ranchers should seek expert advice for master counsel on various issues identified with agribusiness and partnered divisions.

Kisan short message service portal: Here rancher continues getting SMS messages giving data or conveying administration or giving warnings on his versatile from specialists, researchers and officers at different dimensions after once settling on messages on agrarian practices/products of his advantage. To put it plainly, messages are modified dependent on rancher's inclinations in the dialect picked by them.

Existing databases of the agriculturists accessible with focal and state government are being coordinated with the entrance. The individuals who are not enlisted, they have to enlist themselves with the framework. They can enlist themselves by calling the Kisan call fixate on the toll-free number or through online interface or even SMS based enrollment is likewise accessible [7].

The administrations of the gateway incorporate harvest generation, including cultivation, creature farming, dairying and fisheries. It sends messages relating creation perspective as well as advertising of deliver, climate gauge, soil testing and so forth.

The Sandesh Pathak application, grew together by Centre for Development of Advanced Computing (C-DAC) Mumbai, Indian Institutes of Technology (IIT) Madras, IIIT Hyderabad, IIT Kharagpur and C-DAC Thiruvananthapuram will empower SMS messages to be analyze boisterously to assist ranchers who may experience issues in analyzing. It is usable by individuals who can't peruse. A vast population of ranchers has a place with this class. So when they get a SMS message either containing agribusiness related counsel or some other thing, this application will peruse out clearly the substance [7].

The application which is accessible for download from the app store of the Mobile Seva Project of legislature of India, is an Indian dialect SMS reader.

The application is a task propelled by the Indian Government to enable ranchers to peruse messages which might be of the accompanying kinds: Counsel to tackle cultivating issues-creepy crawly, sickness, compost or weed the board; data on climate for example, results and updates on most recent innovation for enhancing yield and significantly more.

Village Knowledge Center (VKC) fills in as data dispersal focus giving moment access to ranchers to most recent data/information accessible in the field of agribusiness, beginning from yield generation to advertising. A "VKC In-control" who cares for the tasks of the VKC keeps an eye on each VKC.

The VRCs are associated with knowledge/expert centers like agricultural universities, skill development institutes and hospitals. More than 6500 projects have been directed by the VRCs in the territories of agriculture/ cultivation, fisheries, livestock, water assets, tele social insurance, awareness programs, women strengthening, supplementary instruction, computer education, micro credit, micro fund, skill improvement/professional preparing for business bolster and so forth. Up until this point, more than five Lakh individuals have benefited VRC services [5].

DISCUSSION

Further developed use of it in farming

Irrigate through advanced cell: Mobile is assuming a major job in observing and controlling yield water system frameworks. With the correct hardware an agriculturist can control his water system frameworks from a telephone or personal computer as opposed to heading to each field.

Moisture sensors in the ground can convey data about the dimension of the dampness present at the specific profundity of the dirt. This gives increasingly exact control of water and different sources of info like manure that are connected by water system turn [6].

Global positioning system (GPS) mapping for a contribution to the field utilizing variable rate innovation, which helps agriculturist in getting to the need for example where they have to put more compost or less, as indicated by the necessity of the dirt. GPS empowered administrations are additionally helping in field documentation about yield, dampness, maps for field waste and so on [6].

Various rancher well disposed (applications) are being propelled by organizations, which helps agriculturists in finding costs for their items, conveying their item, getting soil report and so forth.

One of its best utilization in cultivating is being finished by one vegetable agriculturist outside Hyderabad utilizing webcams to screen the products and to take the researchers ability to address issues without taking them to the field.

Advantages of e-aid to farmers

IT has advanced into the agrarian part and with positive outcomes. To give some examples, here are a portion of its belongings.

By having the important data, ranchers of all shapes and sizes can settle on better and progressively educated choice concerning their agrarian exercises. May it be about who to get their grains from or maybe who to pitch it to, the correspondence channels that data innovation conveys influences generation to up to dissemination less demanding for the ranchers. The trading of learning from different nations and association additionally enables agriculturists to be progressively mindful of elements to consider before settling on their choices [8].

IT has made ready to think of cultivating programming which can monitor crops, predict yields, when to best plant and what to plant, to intercrop or center around only one item or decide the present need of the harvests pretty much everything expected to enhance creation and salary.

By acclimating to the cutting-edge cultivating techniques, ranchers can have better control of their harvests. Picking up data from their homestead is fundamental in supporting its prosperity and fueling further development.

There are a few projects which are made conceivable by IT applications and network association in agribusiness can be expanded too. At the point when a network embraces present day strategies for farming, the creation of nearby merchandise can be expanded.

There are a few spots where individuals significantly advantage from the land and their assets for agribusiness and with IT, there can be enhanced association in neighborhood ranchers which can prompt their locale's in general enhanced generation that may prompt better pay for everybody included.

IT makes the spread of data concerning the most recent farming leaps forward progressively conceivable. At the point when researchers grow as good as ever grains or discover systems to help winter crops end up more grounded against the chilly, ranchers from everywhere throughout the world may profit by similar leaps forward essentially by being associated with whatever is left of the horticultural world. Sharing data to enable everybody to advance is made a lot less demanding through assets made accessible and available by IT.

Farmers have top to bottom information with regards to their exchange. In any case, intrigued people who might be called terrace ranchers may likewise profit by how present-day innovation has changed how horticulture is seen. Developing your own reasonable garden of herbs, organic product trees and other agrarian create can be conceivable in a littler scale. Planting is advantageous in more courses than one and having your very own create even guarantees the freshness and nature of the nourishment your family eats [9].

Exactness agriculture

Satellite cultivating or Site-Specific Crop Management (SSCM) is a cultivating the executive's idea dependent on watching, estimating and reacting to entomb and intra-field inconstancy in harvests.

This strategy centers around using assets ideally to enhance the quality and amount of yields while bringing down the expense of creation. It decreases compost and pesticide use, counteracts soil corruption, uses water ideally and raises efficiency. Internationally, this is finished with the guide of current, eco-accommodating cultivating practices and innovation, including satellite symbolism and data innovation. This development can go far in handling a considerable lot of our nation's homestead ills, including unreasonable utilization of water and different sources of info, which has harmed soil quality separated from making cultivating unfruitful as a calling [10,11].

Issues in effective use of technology

In spite of the fact that bunches of issues like achievability of network in country regions, cost associated with guaranteeing administrations, requirement for fundamental personal computer education and proficiency prevents the quick improvement of e-agriculture, it will be a motor of development in rural India once the underlying hiccups are survived.

The reach of the innovation is still exceptionally poor and huge lump of agriculturists are as yet unmindful about such progressions. The conveyance of advancements isn't uniform all through the nation. Agriculturists of prosperous states are in a bad way like Punjab, Haryana, Maharashtra and the ranchers of in reverse states still practice their deep- rooted methods and information.

The utilization of innovation is being utilized by the effectively rich ranchers and using these administrations they are further flourishing. The little and minimal ranchers are again being forgotten during the time spent improvement.

Due to low proficiency rate among agriculturists and advanced gap, there is an ascent of new class of center man, who give IT administrations to ranchers. They are additionally accepted to twist the data for their own advantage.

The provincial framework for its utilization is likewise not uniform and parcel of local dissimilarity continues.

CONCLUSION

Present days the entrance of market powers in country India is expanding and is potential market. With the various societies and dialects in India, IT gives a decent stage here. Along these lines in future there would be significant raise and supportable improvement in country regions.

ITs are changing every one of the circles of human lives and farming can't be an exemption. ITs presently may go about as an operator for changing agrarian and agriculturist's life by enhancing access of data and sharing learning. The IT apparatuses can change the thoughts, exercises and information of the ranchers. Agriculturists feel enabled and can embrace suitable measures at the critical moment.

With the new expansion of Information Technology and Communication (ITC) activities like Krishivihar, I-kisan, e-kutir, e-sagoo, IT demonstrates AGROWEB, Agropedia, AgrInnovate and so forth. Indian agribusiness has gone too far and built up a few records as far as generation and profitability. IT could change horticulture into a superior prospect as a result of environmental change and decline in the cultivable land.

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REVIEW ARTICLE

A review: Nutritional value of winter vegetables

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Winter vegetables are a significant part of a healthy diet, providing essential vitamins, minerals and antioxidants that support various health aspects. These vegetables, particularly grown in colder climates are rich in vitamins, minerals, fiber and antioxidants that contribute to overall wellness. Vitamins like vitamin A, vitamin B, vitamin C and vitamin K are essential for vision, immune function and skin health. Minerals like potassium, magnesium and iron are essential for various physiological functions. Leafy greens, cole crops, bulb crops and root vegetables are rich in antioxidants and phytochemicals that protect cells from oxidative stress and inflammation. Regular consumption of these vegetables can reduce the risk of chronic diseases and improve dietary patterns, food security and human health. Winter vegetables, particularly leafy greens and root vegetables, are a staple food with significant nutritional qualities that contribute to overall health.

Key Words: *Winter vegetables; Vitamins; Minerals; Antioxidant; Human health*

INTRODUCTION

India is the world's second-largest producer of vegetables, using 10.1 million hectares of land and producing 209.14 million tons of vegetables year. Hardy and nutrient-dense, winter vegetables flourish in colder climes and provide essential nutrients during the cold months. Vegetables are a key component of a diet that is nutrient-rich and well-balanced since they provide so many essential elements that promote overall health and wellness. Rich in vitamins, minerals, fiber and antioxidants, vegetables are vital for maintaining good health and preventing chronic ailments. Vegetables are the most accessible and reasonably priced sources of essential fibers, vitamins, minerals, essential amino acids and chemicals that are notably helpful in preventing illness [1]. Winter vegetables, a staple food have significant nutritional qualities that contribute to overall health [2]. In this in-depth analysis, we will look at the diverse array of nutrients found in vegetables, shedding light on their individual benefits as well as their collective impacts on human health. Vegetables are an excellent source of several vitamins, each of which plays a unique role in maintaining health. Vitamin A is essential for healthy skin, strong immune and clear vision. Good sources of this vitamin include spinach, carrots and sweet potatoes. Rich in antioxidants, vitamin C boosts immunity and encourages the production of collagen. Broccoli, bell peppers and citrus fruits all have high concentrations of it. For strong bones and proper blood coagulation, vitamin K is essential. Dark green vegetables such as Swiss chard and kale are excellent sources of this vitamin.

Minerals are abundant in vegetables and are essential for many physiological functions. Leafy greens high in iron, such as kale and spinach, support the blood's oxygen transport mechanism. Bananas, sweet potatoes and tomatoes are high in potassium, which is necessary to maintain normal blood pressure. Magnesium is abundant in green leafy vegetables like spinach and Swiss chard and is essential for strong muscles and neurons. Vegetables, being high in dietary fiber, aid in maintaining a healthy digestive system and prevent conditions such as constipation. Fiber also helps with weight control by increasing satiety and reducing total calorie intake. Broccoli, brussels sprouts and peas are examples of vegetables high in fiber that improve digestive health and overall well-being. Vegetables are rich in antioxidants and phytochemicals, which protect cells from oxidative stress and inflammation. Tomatoes contain lycopene, a powerful antioxidant that has been connected to a decreased risk of numerous cancers. Among the cruciferous veggies are cauliflower and broccoli. Both plants contain the anti-cancer substance sulforaphane. Flavonoids, which have anti-inflammatory and heart-protective qualities are found in citrus fruits and onions. Leafy greens, such as Swiss chard, kale and spinach, stand out as foods that are very high in nutrients. Vitamins A, C and K, as well as calcium and iron, are all abundant in these greens. When incorporated into the diet, these nutrient-dense greens may provide a multitude of essential nutrients and enhance overall health. cruciferous vegetables, such as brussels sprouts, cabbage and broccoli, provide a number of health benefits. Among these are compounds like as glucosinolates, which have been linked to a lower risk of cancer. These vegetables are also a fantastic source of fiber, vitamins and minerals that support cardiovascular health and the body's detoxification procedures. A diet high in vegetables has been associated with a lower risk of cardiovascular disease in people [3]. Root vegetables high in nutrients, such as carrots, sweet potatoes and beets are also delicious. Sweet potatoes provide a good dose of fiber, vitamins and minerals and carrots being abundant in beta-carotene, aid in eye health maintenance. Beet nitrates have the potential to improve athletic performance by increasing blood flow. Daily vegetable consumption has been clearly associated with better gastrointestinal health, reduced risk of heart disease, stroke, anemia and other disorders [4]. Allium vegetables, such as garlic, onions and leeks are well-known for their distinct flavors and potential health benefits. Garlic in particular has been associated with cardiovascular health since it may lower blood pressure and cholesterol. Onions contain a flavonoid called quercetin, which is anti-inflammatory and antioxidant. The vibrant colors of vegetables sometimes indicate the availability of certain nutrients. Strong skin and a healthy immune system are supported by vitamin C and carotenoids, which are found in abundance in red and orange foods like tomatoes and bell peppers. Purple foods like eggplant and purple cabbage contain compounds called anthocyanins, which have antioxidant and anti-inflammatory properties. Eating a variety of veggies on a regular basis has been linked to a lower risk of acquiring chronic conditions including diabetes, heart disease and various cancers. We explore the many facets of winter vegetables in this social science investigation, looking at their nutritional value and wider societal ramifications. We examine the effects of winter vegetable intake on dietary patterns, food security and community health *via* a social lens. We want to understand the complex relationships between winter vegetables and social well-being through an examination of cultural norms, economic variables and access to nutrient-dense foods.

LITERATURE REVIEW

Nutrients contain in winter vegetables

Lettuce: Lettuce is a leafy green that is high in nutrients. It has the vitamins A, K and C as well as fiber and folate. Because it is low in calories and carbs, it aids with blood sugar balance and weight control. A vital component of a balanced diet, lettuce adds crunch and freshness to salads and wraps and is very adaptable. Lettuce is high in flavonoids, tocopherols and conjugated quercetin. Crozier et al., similarly reported significant variations in flavonol

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concentrations between lettuce cultivars [5]. The popular tiny "round" lettuce was found to have a quercetin concentration of just 11 µg/g fresh weight, while "iceberg" lettuce had a far lower quercetin content. Conversely, the red lettuce cultivar "Lollo Rosso" had 911 µg/g on its outer leaves. Like quercetin, this lettuce's high anthocyanin concentration is a consequence of the phenylpropanoid pathway. This is why the lettuce looks red. Larger concentrations of related compounds, such flavonols, may also be present given the increase of one pathway end-product.

Green peas: While you may eat peas all year round, winter is the best time to eat fresh green peas. Peas are another key food, they are rich in fiber and antioxidants which help prevent gastrointestinal problems and they are excellent sources of plant-based protein. The fact that peas are easy to include into most Indian cuisines is another benefit. Peas have high amounts of vitamins A and B in them. Uncooked peas can also be eaten and doing so has no detrimental health consequences [6]. One excellent source of iron is legumes. In 2010, Trinidad et al., conducted an *in vitro* study on the mineral availability of iron, zinc and calcium in ten native legumes (cowpeas, mung beans, pole sitao, chickpeas, green peas, groundnuts, pigeon peas, kidney beans, lima beans and soyabeans) [7]. Peas, lentils and leafy vegetables are good sources of protein [8].

Cole crops: Cole crops are one of the largest groups of temperate vegetables; this group includes important crops such as brussels sprouts, broccoli, cauliflower and cabbage. Cole crops are rich in vitamin C and a great source of minerals. Many volatile sulfur compounds are the source of cole crops unique taste. It has been proposed that dimethyl trisulfide has a major role in the taste of cooked brassy vegetables. A particularly nice aroma comes from cabbage because to the synigrin glucoside. It's loaded in nutrients. It has high levels of vitamins "A" and "C" and minerals like calcium and phosphorus. It is a vegetable and is used in salads dried and pickled to preserve. The experiment conducted by Hansen et al., revealed a noteworthy variation in the concentration of specific glucose-nolate across the 21 red cabbage cultivars and 6 white cabbage cultivars examined [9]. It was shown that red cabbage cultivars have much higher quantities of glucoraphanin than white cabbage cultivars. The red cabbage types also showed notable differences. "Rodima" exhibited the highest glucoraphanin concentration (7.4 mg/g DW) of the red cultivars examined, while "Primero" had the lowest value (0.6 mg/g DW). When comparing the glucoiberin concentrations of the white and red cabbage cultivars, the white cultivars are much higher. The white cabbage cultivar "Bartolo" had the greatest quantity at 7.4 mg/g dry weight, while the cultivar "Candela" had the lowest amount at 1.7 mg/g dry weight. The red cultivars ranged in dry weight from around 3 mg/g to 0.3 mg/g. Furthermore, it was shown that red cabbages had a substantially higher amount of gluconasturtiin than white cabbage cultivars. The cultivar "Amager Garo" had the greatest content, while the cultivar "Primero" had the lowest, with 1 and 0.1 mg/g dry weight, respectively. In addition to having enough quantities of vitamin B, lump cabbage is rich in minerals and has more protein than other vegetables. Both vitamins "A" and "C" and minerals like calcium and phosphorus are abundant in it. Broccoli is nutrient-rich, consuming one or more servings of broccoli per week has been shown to reduce the incidence of prostate cancer and delay the disease's transition from a localized to an aggressive form [10,11]. Broccoli-rich diets may also reduce the risk of prostate cancer. Brussels sprouts are an extremely nutrient-dense veggie. Appropriate levels of protein, calcium, iron and vitamin A are present. In terms of vitamin content, brussels sprouts and broccoli were evaluated comparably well by Kurlich et al., with high amounts of C and E as well as β-carotene [12]. Known as the Cruciferae or Brassicacea family, cruciferous vegetables include mustards, watercress, cabbage, broccoli, cauliflower, brussels sprouts, kales, kailan, Chinese cabbage, turnip, rutabaga, radish, horseradish and rocket. These vegetables also contain the highest concentrations of glucose-olates in the human diet. The majority of consumers believe that eating a diet high in vegetables is healthy. This is because, in 1997 the World Cancer Research Fund in the United States concluded that, when paired with vegetables high in other phytonutriceuticals, cruciferous diets are likely to protect humans against cancers of the thyroid, colon and rectum in addition to potentially preventing cancers of other organs. Based on one of the biggest and most comprehensive examinations of food and cancer, this conclusion was reached. It has been shown that cruciferous vegetables strong in glucose-nolates, such as broccoli, cabbage, brussels sprouts, kale and others, provide protection against cancers of the lung, prostate, breast and other organs affected by chemicals [11]. Substantial variations were seen between and among these crucifers when the levels of α- and β-, α- and γ-tocopherols as well as vitamin C were assessed in broccoli, brussels sprouts, cabbage, cauliflower, tronchuda and kale [13]. Vitamin C is the most common vitamin among the five crucifers that were investigated. Kale had the highest concentration of these vitamins, with broccoli, cauliflower, cabbage and brussels sprouts following closely after. Genetic factors were shown to account for 79% of the variability in broccoli's β-carotene, 82% of its α-tocopherol and 55% of its vitamin C levels [12]. Crucifers are also an excellent source of folate. Approximately 110-135 and 70-90 µg/100 g, respectively, were found to be among the best vegetable sources of folate, according to research by Scott et al., and Konings et al., [14,15]. Broccoli stores selenium as selenocysteine, which is readily absorbed by human tissue [16]. Selenium-supplemented broccoli has been demonstrated to reduce colon cancer and breast cancers in animal models [17]. According to Kumar et al., the cabbage family of vegetables, which includes cabbage, cauliflower and brussels sprouts has compounds that may help prevent cancer [1].

Onion and garlic: Onions and garlic are not only delicious side dishes, but they are also very nourishing. Both vegetables are low in calories but high in essential nutrients. Onions for instance, are a great source of vitamin C, an antioxidant that supports strong immunity and beautiful skin. Quercetin is another antioxidant that has anti-inflammatory properties. In addition, onions include fiber, potassium and folate, which are essential nutrients for overall well-being, including heart and digestive health. The highest total flavonoid content was found in onion leaves, out of the 62 vegetables that Miean et al., examined [18]. The total flavonoid concentrations of garlic and onion leaves were around 1.0 and 2.7 g/kg dry weight, respectively. Onion leaves contain around 55% quercetin, 31% kaempferol and 14% luteolin as flavonoids. About 95% of the flavonoids in onion bulbs are quercetin; kaempferol is only trace levels [19]. Research indicates that white onion cultivars have a significantly lower quercetin concentration than red onion cultivars, with the bulk of quercetin concentrated in the outer scales. Red onions contained approximately 1350 µg/g of total flavonols, whereas white onions had just around 10 µg/g. According to Herrmann, quercetin primarily appeared as a free-form aglycone in onions [20]. Garlic has some of these nutritional benefits and also has high levels of fiber and vitamin C. One of the most well-known components of garlic is allicin, a sulfur-containing compound that also provides garlic its distinct aroma and certain health advantages. Garlic may have more cardiovascular benefits if allicin lowers blood pressure and cholesterol. It is also believed to possess antimicrobial qualities that aid in the prevention of illnesses. Of the flavonoids in garlic cloves, myricetin makes about 72%, apigenin 23% and quercetin 5% [18]. Several epidemiological studies show that the use of alliums, such onions and garlic and the occurrence of cancer are inversely correlated. A synthesis of case control studies carried out in Italy and Switzerland found that consuming one to seven servings of fish a week reduced the incidence of cancers of the mouth, throat, colon and ovaries [21]. Furthermore, a range of bioactive chemicals found in onions may reduce the occurrence of cardiovascular diseases. A human trial found that consuming the equivalent of three onions in a soup was sufficient to significantly reduce the aggregation of blood platelets [22].

Carrot: Carrots are another vegetable that is generally available throughout the winter. It's a great way to get vitamins and minerals. Carrots can cause shortages in vitamins A, B and C. In addition to other minerals like folate, iron, copper, potassium and more carrots are a great source of important vitamins. Carrots provide several health benefits. Regular consumption improves eyesight, strengthens immunity and wards against cancer. Carrots contain three flavonoids that are uncommon in combination: kaempferol, quercetin and luteolin [23]. Over the course of the last forty years, carrots have experienced a tremendous increase in total carotenoid levels through conventional breeding, reaching 1000 ppm carotenoids on a fresh weight basis.

Radish: A common vegetable for salads and cookery is the radish. It's also eaten as a paratha with curd for breakfast and it tastes strong. Its leaves are often used to cook vegetables. Vitamin C and other minerals are abundant in radishes. Radish should also be avoided by those who have liver illness or jaundice. In addition to being high in fiber, they also include vitamins E, A, C, B6 and K, antioxidants, zinc, phosphorus, potassium, magnesium and calcium. The three primary glucosinolates identified in radish are glucoerucin, glucoraphanin and glucobrassicin [24].

Turnips: Turnips are another one of the greatest winter vegetable selections. One excellent source of vitamin C is turnip greens. It improves lung health

by lowering lung inflammation and emphysema. Turnip consumption also has the added benefit of occasionally treating kidney stones. Eating turnips every day can assist with the problem if you don't have significant stone growth [6].

Beetroot: Beetroot holds a significant position among root vegetables. There are several reasons beets are farmed. Usually, it's used in salads and beverages. The body uses it to make up for its blood deficiency. Magnesium, calcium, potassium, phosphorus, iodine, iron, manganese and vitamins A, C, B1 and B2 are all present in large amounts. They boost immunity since they are high in vitamin C. They really benefit the skin and hair.

Fenugreek: Botany classifies this crop as an annual herbaceous plant that is grown for its seeds and leaves, both dried and fresh. Fenugreek is used in cosmetics, cuisine, medicine and animal feed. Its fresh, green and dried leaves are used as a vegetable in the winter because they are high in iron, sulfur, calcium, magnesium, oil, protein, fiber, carbohydrate and vitamins A, C and nicotine. Its seeds are used as a spice in pickles and vegetables. Fenugreek has a high nutritional content and is used in Ayurveda medicine to treat a variety of illnesses. Research indicates that individuals with diabetes, high cholesterol, diarrhea and dysentery benefit more from consuming seeds [6]. Fenugreek and other Indian green leafy vegetables are good sources of soluble dietary fiber, according to published studies. Consuming more vegetable fiber decreases the risk of cardiovascular diseases, supports a healthy body weight, aids in the maintenance of a healthy digestive system and may even prevent colon cancer [25,26].

Spinach: Being abundant in vitamins and low in calories, spinach is one of the healthiest foods out there. It is one of the foods with the most nutrients. It is a great source of vitamins A and C as well as foliate. Sa'eed et al., claim that heat causes a green's oxalate content to decrease, releasing calcium for the food [27]. While raw spinach is still delicious in salads, cooked spinach has more benefits. These are composed of antioxidants and phenolic compounds, which are secondary metabolites of beneficial plants [1]. Spinach is one of the green veggies that is most often served in Indian families. Spinach is a highly healthy leafy green that may be eaten and helps with many different types of ailments. It also compensates for the deficiency of many vitamin types. Spinach is something you should eat every day. Among the green crops cultivated in India, spinach has a prominent place. Spinach is a crop that is rich in vitamins, minerals and iron. It is used as a green vegetable. While calcium (vitamin A) is plentiful, iron phosphorus (vitamin C) is found in low amounts. Asthma, cancer, stones and scabies may all be avoided with spinach leaves. Because it is antipyretic, blood purifying, healthy and lowers blood pressure, this coolant is great for those with high blood pressure. Lastly, spinach promotes the development of strong hair and skin. Spinach is one of the foods high in fiber [25]. According to studies found in the literature, spinach has a high soluble fiber content. Like other leafy green vegetables, spinach is an excellent source of nutrients. A half-cup of boiled spinach provides 573 micrograms (mcg) of vitamin A or 229% of the recommended daily intake. Some research suggests that spinach might strengthen the heart and lower blood pressure. Fresh for instance, spinach has the highest quantities of calcium (1036 mg/100 g), magnesium (827 mg/100 g), iron (28.4 mg/100 g) and salt (827 mg/100 g). Spinach is a great example of a meal that has relatively high calcium content but that the body can scarcely absorb due to its high oxalate concentration. Even though it is technically correct, marketing spinach as a food high in calcium is deceptive because it is not a very good source of calcium for humans [28].

DISCUSSION

Winter vegetables, are a vital part of a healthy diet, providing essential vitamins, minerals and antioxidants that support various health aspects. These vegetables, especially those grown in colder climates, are rich in vitamins, minerals, fiber and antioxidants that contribute to overall wellness. Vitamins like vitamin A, vitamin B, vitamin C and vitamin K are essential for vision, immune function and skin health, while minerals like potassium, magnesium and iron are essential for physiological functions. Regular consumption of these vegetables can reduce the risk of chronic diseases and improve dietary patterns, food security and human health. Their antioxidant content protects cells from oxidative stress and inflammation, making them a vital part of a balanced diet. Winter vegetables play an important role in maintaining a healthy diet during the colder months, offering an array of essential nutrients that support overall well-being. These vegetables are not only versatile in their culinary uses but also packed with vitamins, minerals and antioxidants that help the body thrive in winter. Carrots are a staple winter vegetable, celebrated for their high beta-carotene content, which the body converts into vitamin A. This nutrient is essential for maintaining healthy vision, supporting immune function and promoting skin health. Additionally, carrots are a good source of dietary fiber, which aids digestion and contributes to gut health. The potassium in carrots also helps regulate blood pressure, making them a well-rounded vegetable for winter nutrition [23].

Spinach is another nutrient-dense winter green, rich in iron, calcium, magnesium and vitamins K, A and folate. The high iron content in spinach is particularly important for red blood cell production, helping to prevent anemia and maintain energy levels during the winter. The calcium and vitamin K in spinach are vital for bone health, while its magnesium content supports muscle and nerve function. Spinach's versatility makes it an excellent addition to a variety of dishes, ensuring that these nutrients are readily available in the diet. Broccoli, a member of the cruciferous vegetable family, is packed with vitamin C, vitamin K, folate, fiber and powerful antioxidants like sulforaphane. Vitamin C is particularly important during the winter months, as it boosts the immune system, helping to ward off colds and other illnesses. The fiber in broccoli aids digestion and supports gut health, while its antioxidants may have cancer-preventive properties, making broccoli a valuable component of a winter diet. Brussels sprouts, another cruciferous vegetable, are rich in fiber, vitamin C, vitamin K and folate. These nutrients contribute to heart health, promote healthy skin and have anti-inflammatory properties. The high fiber content of brussels sprouts supports digestive health and helps maintain a healthy weight by promoting a feeling of fullness. Kale is often touted as a superfood and for good reason. It is exceptionally rich in vitamin K, vitamin C, vitamin A, fiber and antioxidants. These nutrients support a wide range of bodily functions, from bone health to immune function. Kale's high antioxidant content helps combat oxidative stress, which can damage cells and lead to chronic diseases. Incorporating kale into winter meals can provide a significant nutritional boost. Sweet potatoes are another winter favorite, known for their high beta-carotene content, which, like carrots, supports skin health, vision and immune function. They are also rich in vitamin C, potassium and fiber, making them a great source of energy and a valuable addition to a balanced diet. The potassium in sweet potatoes helps regulate blood pressure, while their fiber content aids digestion. Cabbage is a versatile winter vegetable that is high in vitamin C, vitamin K, folate and fiber. It supports digestive health, aids in detoxification and has anti-inflammatory properties. Cabbage is also known for its heart-health benefits, making it a great choice for winter meals.

CONCLUSION

In conclusion, winter vegetables are essential for a balanced diet, providing a diverse array of nutrients that support overall health and wellness. These hardy vegetables, flourishing in colder climates, are rich in essential vitamins like A, C and K and minerals such as potassium, magnesium and iron. Their high antioxidant content helps combat oxidative stress and inflammation, reducing the risk of chronic diseases. Leafy greens like spinach and kale, cruciferous vegetables such as broccoli and brussels sprouts and root vegetables like carrots and sweet potatoes, all contribute to improved immune function, digestive health and cardiovascular wellness. By incorporating these nutrient-dense vegetables into daily meals, individuals can enhance their health, bolster their immune systems and support long-term well-being during the winter months. Their versatility and rich nutritional profiles make winter vegetables a valuable staple in maintaining a healthy and balanced diet.

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REVIEW ARTICLE

Impact of mass media in agriculture: An overview

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Mass media significantly impacts the agricultural sector, influencing information dissemination, community building and sustainable farming practices. It provides farmers with real-time updates on weather forecasts, market trends and agricultural practices, enabling them to optimize their operations and improve yields. Mass media also serves as an educational tool, raising awareness about sustainable farming practices and environmental conservation. Documentaries, educational programs and articles inform farmers about biodiversity, soil health and water conservation. By promoting sustainable practices, mass media encourages farmers to adopt methods that enhance productivity while protecting the environment. This educational aspect is significant in encouraging a responsible approach to agriculture, ensuring sustainable practices for future generations. The impact of mass media on agriculture is multifaceted, enhancing communication, education and community engagement. As technology evolves, the influence of mass media in agriculture will likely expand, providing more opportunities for farmers to thrive in an ever-changing landscape.

Key Words: *Mass media; Information; Sustainable farming; Farmers; Agriculture*

INTRODUCTION

Mass media plays a pivotal role in the agricultural sector, serving as a vital conduit for information dissemination, education and advocacy. Its influence is far-reaching, impacting the decisions, practices and overall development of agriculture worldwide. In emerging nations, the majority of people still rely on "traditional mass media" including radio, television and newspapers. Accordingly, these three media outlets could be useful for spreading agricultural-related information [1]. Educating the public about new government initiatives, methods and technology is one of the main roles of mass media in agriculture. Numerous media platforms such as radio, television, advertising, movies, the internet, newspapers, magazines and so on are among the technologies used in this communication [2]. Mass media is important in helping farmers receive developments in contemporary agriculture [3]. Furthermore, by drawing attention to certain concerns, the media can improve people's understanding and alter their behavior [4,5]. Newspapers provide additional benefits, such as stable form a wealth of information and authority, even if radio and television are the mass media formats with the quickest rates of growth [6]. Additionally, the media serves as a link between farmers and resources and markets. It offers vital details on demand patterns, market pricing and the most effective ways to promote agricultural goods. This relationship aids farmers in making wise choices and maximizing their earnings. Furthermore, media outlets provide farmers with access to professional viewpoints, guidance and solutions to issues in agriculture, helping them to address obstacles more skillfully. The media is very important for lobbying and influencing policy. Through drawing attention to problems that farmers confront, such the effects of climate change, water shortages and financial restrictions the media may persuade decision-makers to take these issues seriously. By advocating for farmers, we can make sure that their needs are met and that their voices are heard. On the other hand, the media also supports government programs and policies meant to assist farmers and make sure they are aware of the advantages that are accessible to them. In several nations, grower communities decision-making and the progress of agriculture and rural areas have benefited from the usage of Information and Communication Technologies (ICTs) [7-9].

Through new technologies that are unique to producers, ICTs have significantly changed agricultural improvement and relocation skills and knowledge [10]. In addition to the potential for ICT to disseminate agriculturally efficient information among producer's other media such as radio, television, mobile phones and the internet can also facilitate the exchange of pertinent and appropriate materials that promote the efficient and productive use of resources [11,12]. The integration of technology with mass media has further revolutionized agricultural communication. Digital media including social media platforms, mobile apps and websites offer real-time updates and interactive platforms for farmers to engage with experts and peers. This technological integration has made information more accessible and timely, allowing farmers to adapt quickly to changing conditions. However, traditional media such as television and radio still play a significant role particularly in rural areas where access to digital technology may be limited. Programs customized to local languages and cultures enhance understanding and adoption among diverse audiences.

LITERATURE REVIEW

Mass media plays a significant role in the dissemination of agricultural information, influencing the practices, decisions and overall development of the agricultural sector. Here's a review of the role of mass media in agriculture:

Information dissemination

Awareness creation: Mass media helps raise awareness about new agricultural technologies, practices and government schemes. It reaches a wide audience, ensuring that farmers are informed about innovations that can enhance productivity.

Education and training: Educational programs broadcasted through radio, television and online platforms provide farmers with knowledge about improved farming techniques, pest management and sustainable practices.

Advocacy and policy influence

Highlighting issues: Media can bring attention to challenges faced by farmers, such as climate change impacts, water scarcity and financial issues, influencing policymakers to address these concerns.

Promoting policies: Government policies and initiatives aimed at supporting farmers are communicated through mass media, ensuring that farmers are aware of the benefits available to them.

Technological integration

Digital media: The rise of digital media and mobile technology has revolutionized the way agricultural information is shared. Social media platforms, mobile apps and websites offer real-time updates and interactive platforms for farmers to engage with experts and peers.

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Television and radio: Traditional media still play a significant role in rural areas where access to digital technology may be limited. Programs customized to local languages and cultures enhance understanding and adoption.

Behavioral change and adoption

Influencing attitudes: Media campaigns can change perceptions and attitudes towards certain agricultural practices, encouraging the adoption of environmentally friendly and economically beneficial methods.

Success stories: Sharing success stories and testimonials of farmers who have benefited from adopting new technologies or practices can motivate others to follow suit.

Challenges and limitations

Access and literacy: Not all farmers have access to mass media or the literacy level required to fully benefit from the information provided.

Content relevance: Information must be relevant and customized to local contexts to be effective. Generic content may not address specific regional agricultural challenges.

Use of newspaper in agriculture

Newspapers are important for providing the public with vital information, but there are still worries around the world that they will prioritize political, entertainment and advertising over development issues like agriculture [13]. According to a Nigerian survey, newspapers don't focus much on agriculture. 36 out of 750 agriculture news stories (4.8%) were featured on the first page. Oladele reported that public media in Botswana cover agricultural news less frequently than private publications. Newspapers typically don't provide a lot of information on agriculture [14]. According to Rolle et al., there are other means to get the most recent information on agriculture outside of periodicals, newspapers and pamphlets such as electronic media, television, mobile phones and radio [15].

Use of radio in agriculture

Radio has been a significant tool in agriculture, providing farmers with vital information and support, especially in rural and remote areas. Its widespread reach, accessibility and ability to deliver timely information make it an effective medium for agricultural communication. Radio plays a vital role in the dissemination of critical information, including market pricing and weather predictions, which is one of its main advantages. Farmers may make better marketing decisions and increase profitability by using market pricing information, which they can use in conjunction with timely weather updates to assist them prepare for planting, harvesting and other operations. The study was concluded by Okwu et al., and it is evident that radio and agricultural initiatives are effective [16]. The majority of farmers like taking part in agricultural programs, according to the statistics which suggests that most producers tune in to radio programs about plants and agronomic items. Moreover, some farmers like hearing about cattle expertise. Radio transmission is still widely used by farmers in rural areas. A lot of farmers rely on radio and newspapers. According to Zhang et al., these broadcast networks have the potential to enhance agricultural development skills and knowledge while serving as a vital conduit for critical information among rural producers [17].

In India's rural agricultural markets, where there isn't a consistent and reliable electricity supply in remote and rural locations, it serves as a potent communication tool. The radio is the only source of information, entertainment and education that people can rely on. For instance, All India Radio (AIR) operates a number of radio stations under the "Kisanvani" concept. The goal is to provide local farmers with up-to-date information regarding weather reports, daily market pricing and other micro-level details in their individual areas. Kisanvani is currently broadcast from 96 AIR stations located all across the nation. "Kisanvani, Samruddhi, Krishi jagat and Suno kisan" is one of the several programs [18].

Use of television in agriculture

Television has become an indispensable tool in the field of agriculture, playing a pivotal role in disseminating information, providing education and encouraging community engagement among farmers. With its unique ability to deliver both visual and auditory content, television offers a powerful medium for conveying complex information in a manner that is both engaging and easy to understand. Because of its influence and scope, it has proven to be a useful instrument for promoting innovations and sustainable farming methods. Without a doubt, television cannot provide the most recent agricultural facts. The findings demonstrate that television is a useful medium for distributing current information, such as news or the greatest knowledge available on wheat, seeds and soil [19]. Television has been a vital tool for spreading the most accurate information about the agriculture industry in Ethiopia and India. It has been noted that agricultural farmers may readily receive improved information by viewing television programs related to farming [20]. All members of society may obtain knowledge and skills *via* television, which also helps farmers become more knowledgeable about the use of new technology in agriculture and transmits content that grabs viewer's interest. Also a lot of people rely on the media to provide them with the most recent information on health, education and agriculture [21]. It is observed that many developing nations have set up a number of communication hubs to spread the word to farmers about the benefits of agriculture. Nonetheless, governments have established agricultural information clearinghouses in several nations. Moreover, producers in developing nations can obtain the most agricultural knowledge *via* television [22]. Television directors and producers will devise new strategies for agricultural growth in order to generate ideas for agricultural development from the standpoint of rural and agricultural progress [21].

Use of social media in agriculture

Social media has become an invaluable tool in agriculture, transforming how farmers connect, share information and promote their products. Platforms like facebook, twitter, instagram and linkedin allow farmers to engage with a broader audience, including consumers, suppliers and industry experts. Farmers may promote a favorable image of agriculture by using social media to highlight sustainable agricultural methods, share success stories and highlight their practices. Social media is the term for digital devices that are mostly based on the internet and are used by individuals to share and discuss data. It makes reference to knowledge, opinions and digital networks allow for the sharing and discussion of multimedia, music and video. Social media components that make them indispensable and accessible. Easy tools exist to enhance verbal communication gain access *via* mass non-public, mass self and mass mobile phone communications. an extensive network of weak links to ensure the receipt of new ideas. In essence, new media is all about what is popular and viral and the most popular platforms these days are youtube, facebook and instagram as they are easily available to anyone. In a research by Thakur et al., social media platforms used in agricultural communication activities were analytically tested [23]. The results showed that users preferred whatsapp over facebook because of its advantages over facebook, including ease, privacy and fewer data usage. Information quality, timeliness and accuracy will all increase as a result of social media technologies connecting the farming community with agricultural organizations. This promotes continuing communication with the agricultural community and the sharing of information in both directions. It also has several drawbacks, such a high frequency of pointless messages, excessive data use and spotty Internet access. According to Tamizhkumaran et al., youtube has a lot of potential for advising and extension services [24]. Client attention is drawn to graphics and videos that provide important information. Positive feedback may be obtained when extension agents respond to customer remarks, enabling two-way contact. State Agricultural University (SAU) and Krishi Vigyan Kendras (KVK's) can lead even the on-farm studies and front-line demonstrations to investigate the profitability of youtube. The use of social media by stakeholders in the agriculture industry is increasing. Professionals, researchers and other stakeholders in the agricultural sector are using social media at an increasing rate. Buying and selling of agricultural goods is made possible by the usage of internet media in the agricultural sector. Social media improves agriculture's marketing, education and communication while linking farmers with customers and the larger agricultural community. This allows farmers to innovate and adapt in a fast changing business.

DISCUSSION

Modern media

Impact of internet in agriculture: The use of the internet in agriculture has transformed the sector, enhancing productivity and efficiency. Farmers now have instant access to a wealth of information, allowing them to stay updated on best practices, pest management and crop health. Precision agriculture has emerged, utilizing sensors, drones and satellite imagery to monitor field

conditions. This data shared *via* the internet, enables informed decisions about irrigation and fertilization leading to increased yields. Moreover, the internet facilitates market access through e-commerce platforms, allowing farmers to sell directly to consumers and research market prices. As farmers communicate through social media and online forums to exchange experiences and seek advice, networking and collaboration have also improved. With the use of online learning resources and training materials, farmers may enhance their skills by using new methods and technologies. Indian gardeners are very internet literate. According to Luqman et al., growers are already using a range of websites to obtain essential information on how to apply pesticides in their agricultural areas in an appropriate manner [12]. The most important information on agriculture and other related topics may be found online completed the study, demonstrating that research on the internet may also be used to determine the function of intermediaries [12,17,25]. Although communities in Bangladesh's development network initiative lacked instant access to the internet, staff assisted them in identifying their requirements. Growers contact the Pallitathya Krishi Resource and Information Center (KRIC) with user questions *via* their phones. Operators use the internet system in tandem to reply to producers experiencing agricultural challenges and attempt to resolve their issues. According to current surveys, 94% of Malaysian producers utilize the internet to receive agricultural information, while 85% get the most recent information through text messaging. Furthermore, mail and internet servers as well as projects for grower's applications have been developed in India and the center gives farmers access to the most recent agricultural news. In remote locations, network services are connected using cable. The percentage of producers who lack literacy and knowledge of computer systems ranges from 85%-92%. Additionally, grower trainers have been chosen to instruct growers in order to transmit knowledge *via* the internet. In this scenario, farmers would not think twice to learn new information about using online resources and about markets and pesticides [4,26]. Additionally, farmers may sell directly to customers and investigate market pricing to the internet's e-commerce platforms, which make it easier to access markets. As farmers communicate through social media and online forums to exchange experiences and seek advice, networking and collaboration have also improved. Farmers may improve their abilities by adopting new technology and techniques with the help of online education and training tools.

Impact of mobile phone in agriculture: The use of mobile phones in agriculture has revolutionized farming practices, enhancing productivity and connectivity for farmers. With instant access to vital information, farmers can receive real-time updates on weather forecasts, market prices and pest management through Short Message Service (SMS) alerts and mobile applications. They may use this knowledge to make well-informed decisions on planting and harvesting. Additionally, mobile phones allow for direct contact between suppliers and customers, which lessens the need for middlemen and improves the negotiating position on prices. Farmers may also use mobile devices to receive advisory services from agricultural groups, which enables them to consult experts on sustainable methods and crop management. Another trial was finished in Ghana, where fruit producers were given smartphones to connect with buyers, sell their crops in advance, interact with consumers and get feedback. Growers may easily communicate with customers directly using smartphones and they receive greater evaluations directly from customers and agents. Smartphones also provide growers another advantage. They get in touch with them immediately and inquire about their agricultural output pace rather than visiting the market. Farmers stand to benefit financially, energetically and temporally from this [12,27,28]. Small farmers now have access to small business facilities and information about the market and weather in remote locations with smartphones. Growers that use cellphones to go with customers and offer their products at higher prices see a significant increase in productivity and revenue [19]. Reports state that producers now have a framework in place for disseminating and receiving updated information on agricultural productivity in cellphones. Many farmers currently use cellphones for many purposes and one of their uses is to get the market price for agricultural products. However, some openly communicate with clients in order to sell their commodities and products at premium rates. Moreover, producers use SMS systems to receive the most recent information about weather conditions and chemicals on their farms [19,29]. Without a doubt, cell phones were utilized in a variety of community sectors, including farming, health, education and rural development to support the economic advancement of developed countries. Mass media has the impact of empowering farmer's organizations in isolated locations and providing them with market knowledge. Additionally, producers reach out to consumers in a variety of urban marketplaces, selling their produce wherever they discover a competitive price [17,30]. Smartphones and other wireless devices were also used in the weather and climate monitoring system, which has greatly improved the income, level of awareness and acceptance in many areas. Additionally, these new services need to be familiarized with the agriculture sector so that producers may receive the most up-to-date techniques for modernizing their farming practices and advancing rural areas. Staff members have provided the newest wireless multi-hop for several features to interact with each other and handle issues with agricultural and rural development by using ICTs without experiencing any discomfort [31,32].

Mass media plays a significant role in shaping various sectors of society and agriculture is no exception. The influence of mass media on agriculture is extreme, affecting everything from information dissemination to community building. This overview explores the multifaceted impact of mass media on the agricultural sector, highlighting its significance in modern farming practices. One of the primary functions of mass media is the dissemination of information. In agriculture, timely access to information is vital for farmers to make informed decisions. Mass media channels, including television, radio, newspapers and online platforms, provide farmers with essential updates on weather forecasts, market trends and agricultural practices. For instance, farmers can learn about the best planting times, pest control methods and crop management techniques through agricultural programs and news segments. This access to real-time information helps farmers optimize their operations and improve yields. Mass media serves as an educational tool, raising awareness about sustainable farming practices and environmental conservation. Documentaries, educational programs and articles can inform farmers about the importance of biodiversity, soil health and water conservation. By promoting sustainable practices, mass media encourages farmers to adopt methods that not only enhance productivity but also protect the environment. This educational aspect is important in encouraging a more responsible approach to agriculture, ensuring that farming practices are sustainable for future generations. The impact of mass media on agriculture is significant and multifaceted. By enhancing communication, education and community engagement, mass media plays a vital role in modernizing the agricultural sector. As technology continues to evolve, the influence of mass media in agriculture will likely expand, providing even more opportunities for farmers to thrive in an ever-changing landscape.

CONCLUSION

In conclusion, mass media is an indispensable tool for transforming agriculture by providing essential information, encouraging innovation and advocating for policy changes. The agriculture industry is greatly impacted by mass media, which gives farmers chances to enhance their farming methods. With the help of its real-time updates on market trends, weather predictions and agricultural methods, farmers are able to increase yields and streamline their operations. The media may also be used as a teaching tool to promote environmental preservation and sustainable agricultural methods. A responsible approach to agriculture is promoted *via* documentaries, educational programs and publications that educate farmers about biodiversity, soil health and water conservation. Mass media's impact on agriculture will probably grow as technology develops, giving farmers more chances to prosper in a constantly shifting environment. All things considered the mass media is extremely important in influencing many facets of society, including agriculture.

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An Overview towards Botanicals from Medicinal Plants in Stored Insects

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The use of synthetic chemical insecticides is not allowed or is used restrictively because of the problem of residues and the health risks of consumers. With this in mind, plants are needed that can provide potential alternatives to the currently used insecticides, as they are a rich source of bioactive molecules. Available literature indicates that the plant could be a source of new insecticides. Preventing food loss during post-harvest storage is of the utmost economic importance. Integrated pest management is now a widely accepted pest management strategy, including post-harvest pest management using chemical insecticides with disinfectants. Therefore, there is great potential for insecticidal compounds derived from plants. This article focuses on the current status of botanical insecticides as grain protectors and how they work. The control of this insect is highly dependent on the use of synthetic insecticides and disinfectants. But its widespread use has created serious problems. The increasing resistance of stored product insects to conventional synthetic pesticides, along with growing concerns over environmental and human health impacts, has spurred interest in alternative pest management strategies. Botanicals derived from medicinal plants have emerged as promising candidates due to their diverse bioactive properties and eco-friendly nature. This review provides a comprehensive overview of the current knowledge on the use of botanical extracts for controlling stored insects. It discusses the various modes of action, including repellency, toxicity, and growth inhibition, and highlights the most effective plant species and their phytochemical constituents.

Keywords: Medicinal; plants; disinfectant; insecticide; health risks; compounds; dependent.

1. INTRODUCTION

“The loss of grain due to insect attacks during storage is a serious problem, especially in developing countries. Insect losses are more than direct losses. High content of insect remains preserved cereals that are not fit for human consumption and food loss and in terms of quality and quantity. Changes caused by infection of insects during storage, the environment can cause hot, wet "hot spots" that suitable storage conditions for mushrooms that cause additional losses. It is estimated that more than 20,000 types of fields and storage pests destroy about a third of the world food production worth more than $ 100 billion a year of which the largest losses (43%) in developing” [1-2]. “Natural products from plants are shown as powerful two-rational alternatives to synthetic insecticides for integrated management of insects after the harvest. Pesticide plants, as an alternative to synthetic pesticides, are known for their non-cytotoxicity, their ease of biodegradation and their modeling of host metabolism. Pesticide compounds grow quickly, making them greener than synthetic compounds” [3-5]. “In India, there is a high availability of plants that have been characterized by their efficiency, growth, proliferation and low availability” [6,7]. “In the 1960s, their negative impact on the environment and human health became apparent. The reasons for using synthetic pesticides are their direct impact on pests, which eventually led to trade in agricultural products with pesticide residues. More than 600 species are considered pests of stored products. Among insects, the main pests are roaches, ticks, and beetles. Beetles are the largest taxon of insects and the number one order of stored product pests” [8]. “In addition, this group of insects is often resistant to insecticides and can survive in dry conditions and absorb water from poorly hydrated products. Therefore, their population is difficult to control in food storage areas. Different groups of insecticides are used against pests of coleopterans (cockroaches and ulcers), such as synthetic insecticides, fungal substances and substances of plant origin (for example, essential oils or alkaloids). Natural products make up a small percentage of the currently used insecticides” [9-11]. In some cases, we have not fully discussed some active compounds due to inconsistencies in the available data. However, if necessary, a brief overview was provided. We are also trying to discuss possible methods of using bio insecticides to protect stored crops, as well as future use of plant compounds in the future to protect stored crops. During severe infestations, skin and submerged bodies accumulate in fluffy masses which can explode. He is an ordinary resident of household dust and is very allergic [12-15]. A vacuum cleaner is required if the sites are severely infected. These signs indicate that the storage conditions are too humid. Contaminated materials should be

Table 1. List of grain pests and their life cycle

Pest Name	Common Host Grains	Life Cycle Stages	Duration of Life Cycle	Key Characteristics
Rice Weevil	Rice, Wheat, Maize	Egg, Larva, Pupa, Adult	26-32 days	Females lay eggs inside the grain kernel; larvae feed inside the grain.
Lesser Grain Borer	Wheat, Barley, Rice	Egg, Larva, Pupa, Adult	30-45 days	Highly destructive; bore holes in grains during larval and adult stages.
Red Flour Beetle	Wheat, Maize, Processed Grains	Egg, Larva, Pupa, Adult	20-25 days	Feeds on broken or damaged grains; thrives in stored grain products.
Sawtoothed Grain Beetle	Oats, Corn, Processed Grains	Egg, Larva, Pupa, Adult	30-50 days	Flattened body allows it to penetrate tight spaces in grain storage.
Granary Weevil	Wheat, Barley, Corn	Egg, Larva, Pupa, Adult	35-40 days	Adults cannot fly; larvae feed entirely within the grain kernel.
Indian Meal Moth	Maize, Rice, Processed Grains	Egg, Larva (Caterpillar), Pupa, Adult	28-35 days	Caterpillars create silk webs in stored products, contaminating food.
Angoumois Grain Moth	Wheat, Corn, Barley	Egg, Larva, Pupa, Adult	4-6 weeks	Eggs are laid on grain surface; larvae bore into kernels to feed.
Khapra Beetle	Rice, Wheat, Barley, Maize	Egg, Larva, Pupa, Adult	4-6 months	Highly resistant to starvation and desiccation; major quarantine pest.
Maize Weevil	Maize, Wheat, Barley	Egg, Larva, Pupa, Adult	30-45 days	Infests whole grains; adult weevils are capable of flight.
Confused Flour Beetle	Wheat, Corn, Barley	Egg, Larva, Pupa, Adult	26-35 days	Feeds on damaged grains and processed products; common in flour mills.

Source: Shadia 2011 [7]

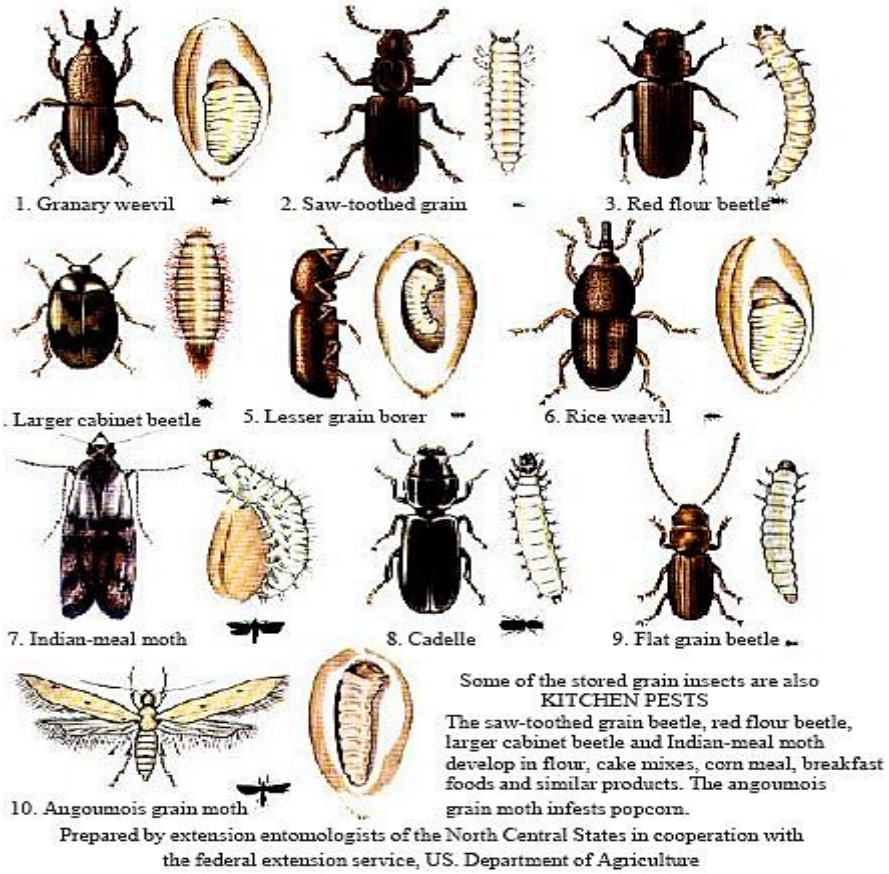


Fig. 1. Microphotographs of kitchen pests

removed and contaminated areas should be thoroughly cleaned. Botanical insecticides currently play only a minor role in insect control and plant protection; increasingly stringent legal requirements in many jurisdictions have prevented a handful of botanists from entering the market in North America and Europe for the past 20 years [16-19]. However, public health requirements and regulations create opportunities for the use of plant products in industrialized countries, in situations where human and animal health is critical, to combat pests in and around homes and gardens, commercial kitchens, and storage. food and meal. in pets [20-23].

2. USES OF BOTANICALS FOR STORED INSECTS

"The biological nature of botanical pesticides accelerates their degradation and therefore does not accumulate in the environment, for example in water and soil, thereby eliminating contamination risks" [24]. "Vegetables have been used since time immemorial to protect stored food from common pests. They act as repellents, antioxidants, toxins and act as natural defenders of grains, acting as chemo stimulants / reproduction inhibitors or inhibitors of insect growth and development" [25,26]. "The concept of using natural sources to a store of various household items has been around for centuries. When modern means were not available. Here evidence of ash, sand, herbs, and herbs used in ancient civilization that was used for expansion shelf life of many foods. Many of these practices they find their confidence even in the modern era, as these methods they are profitable and sustainable. The main activity is due to the presence of volatile lipophilic essential oils secondary metabolites. Many spices and herbs and their extracts are known to have insecticidal properties, which often present in the essential oil fraction" [27-31].

3. TRADITIONAL METHODS FOR STORED INSECTS

"Only some other plant materials show a decrease in commercial use as insecticides, as

the wood of the Caribbean tree *Ryania speciosa* (Salicaceae) contains a number of unique alkaloids that block neuromuscular compounds. Shredded stem wood containing Al% ryanodine and its alkaloid analogs was used to produce organic fruits. *Quassia amara* (Simaroubaceae), a small tree from Brazil, contains bitter triterpenoids. The wood chips and bark of the land of this species and the associated tree Ailanthus altissima have traditionally been used as an insecticide. Sabadilla is a powder based on ground seeds of *Schoenocaulon officinale* (Melanthiaceae), a plant from South America. Pure active substances, the steroid type alkaloids, are quite toxic to mammals, but, like rotenone, the concentration of alkaloids in powdered seeds is quite low, which provides a margin of safety for the user" [32-35].

a. Pyrethrum: Pyrethrum is the most widely used botanical insecticide in the world and is known as a rapidly disintegrating household spray.
b. Pyrethroids: It is synthetic materials designed to imitate natural pyrethrum but are much more toxic and long lasting.
c. Rotenone: Rotenone is an isoflavonoid obtained from the roots or rhizomes of tropical legumes in the genera Derris, *Lonchocarpus* and *Tephrosia*.
d. Nicotinoids: They have been previously referred to as nitro-guanidines, neonicotinyls, neonicotinoids, chloronicotines and more recently as the chloronicotinyls.

4. FUMIGATION

The currently used fumigants, phosphine, methyl bromide, This is consequence, there is an increasing necessitates for development of safe alternative that could replace the toxic fumigation against stored product insecticides. *Sitophilus zeamais* is and the red-flour beetle, *Tribolium castaneum* and demonstrates both repellent and fumigant properties. The exact mode of action of these oils as fumigant is unknown but the oils mainly act in the vapor phase via respiratory system. Alkaloids isolated from *Annona squamosa* have shown larvicidal growth-regulating and chemosterilant activities against *Anopheles stephensi*, *Callosobruchus chinensis*, causing nearly 100% sterility at a concentration of 1.5%. Fumigation plays a major role in insect pest elimination in stored products. Currently, phosphine (from metal phosphide preparations, cylinderized formulations and on-site generators) and methyl bromide (available in cylinders and metal cans) are the two common fumigants used for stored-product protection world over.

The following areas of research need attention for the exploitation of these natural products as alternative fumigants for stored-product insect control:

1. Stability of plant products as fumigants.
2. Screening of plant essential oils/compounds for fumigant toxicity must include egg and pupal stages, diapason larvae or mixed-age cultures of target insect species
3. Validation of mixtures containing carrier gases or adjuvants for essential oils.
4. Sorption and tainting aspects must be addressed for potent essential oils/components with different types of food commodities
5. Fumigant toxicity of essential oils/constituents to *C. cephalonica*, *A. fasciculatus*, *C. serratus*, *Cryptolestes* spp. and insect pests of animal products (except D. maculatus).
6. Fumigant action of compounds from neem seed or oil, seaweeds and other marine natural products needs to be investigated [36-39].

5. FUTURE OF BOTANICALS

Vegetables are useful in the case of documented resistance of the diamond moth to *Bacillus thuringiensis* and spinosad because of. Plants are useful in case of documented resistance to diamond moths against *Bacillus thuringiensis* and spinosad due to overuse [40]. Vegetables help prevent the discharge of thousands of tons of pesticides to Earth; they are safer for the user and for the environment because they decompose by microorganisms and decompose into harmless compounds in a matter of hours or days in the presence of sunlight.

6. INSECTICIDAL ACTIVITY

The percentage of variation in the sensitivity of stored grain insect pests is high in response to toxicity of volatile compounds, currently control of stored-product insects of cereals in store were ... In this work extended to the search of insecticidal activity are observed are, *Morinda lucida*, *Callosobruchus maculatus*, rice weevil, *Sitophilus zeamais* Motschulsky., *Sitophilus oryzae* L.,

Callosobruchus maculatus, *S. oryzae*, *R. dominica*, *P. interpunctella*, So, we recommended using botanical insecticidal and being promoted and research is being conducted to find new sources of botanical insecticides. Some recent publications are cited in the ascending order which covers the studies on Botanicals from Medicinal Plants in Stored Insects, case studies, research and review communications are as follows:

7. CONCLUSION

The fact that small holder farmers have the knowledge of using pesticide plants which they hardly use, there is a need of a research based solution on better ways to make the knowledge useful. Practical research based in field situation and that directly involve small scale farmers is important to put into practice experts' understanding. There have been many laboratory studies of plant products as fumigants against insect pests of stored foods. In addition to toxicity tests, special attention was paid to elucidating the way it acts on insects. For some natural compounds, the effect on food quality, germination and seedling growth was studied. However, the following research areas require special attention to study these natural products as alternative fumigants for controlling insects in stored foods.the utilization of botanicals derived from medicinal plants presents a promising and sustainable approach to managing stored insect pests. These natural compounds offer a safer alternative to synthetic pesticides, reducing the risk of environmental contamination and human health hazards. The diverse modes of action exhibited by botanical extracts, such as repellency, toxicity, and growth inhibition, contribute to their effectiveness in pest control. However, to fully realize the potential of botanicals, further research is needed to identify the most potent plant species, optimize extraction methods, and understand the mechanisms underlying their insecticidal properties. Additionally, the development of standardized formulations and field trials will be crucial for the successful integration of botanicals into pest management programs. By continuing to explore and harness the bioactive properties of medicinal plants, we can enhance sustainable agricultural practices and ensure food security in the face of increasing pest pressures.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors hve declared that no competing interests exist.

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REVIEW ARTICLE

An overview of the effect of integrated nutrient management on vegetable crops

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The overview on the effects of Integrated Nutrient Management (INM) on vegetable crops highlights its multifaceted benefits. INM integrates organic and chemical fertilizers, enhancing soil fertility and structure while optimizing nutrient supply to vegetable crops. INM practices are important in vegetable crop production, enhancing the quantity and quality of crops like tomato, brinjal, chilli, radish, carrots, cabbage, cauliflower, broccoli, okra, cucumber pumpkin, melons, gourd and leafy vegetables. By combining natural and inorganic fertilizers with bio-fertilizers, INM methods reduce input costs and enhance crop quality and nutrition. This sustainable approach optimizes nutrient use efficiency, enhances soil health, reduces environmental pollution and contributes to overall sustainability. It is essential for researchers, policymakers and farmers to promote and encourage INM practices for a more productive and environmentally friendly vegetable farming sector. This balanced nutrition leads to increased vegetables yields, improved crop quality and enhanced nutrient use efficiency. Additionally, INM practices promote sustainable soil management, reducing environmental impact and encouraging resilience to abiotic stresses. By minimizing reliance on synthetic inputs, INM contributes to economic viability for growers while preserving natural resources.

Key Words: *Sustainability; Soil health; Natural resources; Vegetables yield*

INTRODUCTION

Integrated Nutrient Management (INM) is pivotal for optimizing vegetable crop productivity while ensuring environmental sustainability. By combining organic and inorganic fertilizers alongside microbial inoculants, INM enhances soil fertility and structure, encouraging strong plant growth and higher yields. By limiting losses and the hazards of environmental contamination associated with synthetic fertilizers, this strategy maximizes nutrient efficiency. As so, it improves soil quality, crop water uptake efficiency and soil health. Furthermore, INM reduces the need for pharmaceutical treatments by encouraging resilience to pests and environmental challenges. Notably, the method improves crop quality, satisfying customer demands for superior, nutrient-dense fruit. In terms of economics, INM maximizes input costs and supports vegetable farming's long-term viability. It is often known that vegetables are an essential dietary supplement for preserving good health and guaranteeing nutritional security. They are significant providers of proteins, carbs, minerals and vitamins. Integrated nutrient management refers to applying both organic and inorganic fertilizers to increase crop yield. Essentially, the INM approach involves applying synthetic fertilizers in addition to agricultural wastes, organic manures, biofertilizers and other biologically related materials in an equivalent ratio [1]. Farmers that cannot afford to utilize chemical fertilization to supply nutrients for any crop can also benefit from the INM approach. In order to boost agricultural output and lessen soil erosion, it also seeks to enhance the biological, mechanical, hydrological and physical qualities of the land [2]. The use of nitrogenous fertilizers excessively or carelessly is detrimental to crop productivity and soil health. Therefore, the application of biofertilizer and organic manure in moderation in addition to chemical fertilizers promotes soil fertility maintenance and lucrative and sustainable crop production [3]. When viewed appropriately, integrated nutrition management can help improve the quantity and caliber of vegetables produced [4]. By combining different nutrient sources, the INM strategy seeks to maximize vegetable crop nutrient usage efficiency. Using both natural and artificial fertilizers in addition to other management techniques, this strategy guarantees crop production that is both ecologically benign and sustainable. INM has drawn a lot of attention lately and is now a significant part of managing vegetable crops [5].

Need of integrated nutrient management in vegetable crops production

Improved soil fertility: In addition to chemical fertilizers, the regular use of organic manures such compost, farmyard manure and green manure helps enhance the fertility, texture and structure of the soil. Better nutrient availability, aeration and water retention result from this, all of which are essential for the growth and development of vegetable crops.

Increased yield and quality: Increased crop yields and better quality characteristics, such vegetable size, color, taste and nutritional content are frequently the outcomes of proper nutrient management using integrated nutrient management. Optimal plant growth and development are supported by balanced nutrition, which raises productivity and produces goods that may be sold.

Enhanced nutrient availability: INM ensures a balanced supply of essential nutrients, including Nitrogen (N), Phosphorus (P), Potassium (K), micronutrients and organic matter. This balanced nutrition promotes vigorous vegetative growth, root development, flowering and fruit set in vegetable crops.

Enhanced soil health: Through the addition of organic matter and the development of beneficial microbial communities, INM methods increase biological activity in the soil. This promotes improved nitrogen cycling, soil health and the long-term sustainability of vegetable cropping systems. It also inhibits soil-borne diseases.

Resistance to abiotic stress: Vegetable crops are more resilient to abiotic stressors like salt, drought and high temperature changes when they are properly nourished, especially when it comes to balanced levels of macro- and micronutrients. Plants that receive proper nutrition are more resilient to environmental shocks and can continue to produce even under difficult circumstances.

Reduced nutrient losses: INM assists in lowering nutrient losses due to volatilization, runoff and leaching by using organic nutrient sources and effective nutrient management techniques. By doing this, the chance of environmental contamination is reduced, nutrient utilization is enhanced and natural resources are preserved.

Improved economic returns: In spite of the possibility of greater upfront expenses associated with organic inputs and management techniques, INM usually yields longer-term advantages. For vegetable producers, more yields,

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better quality, less input needed and more environmental sustainability all translate into higher financial benefits.

Adaptation to climate change: INM techniques can improve crop resilience, water usage efficiency and soil carbon sequestration, all of which can help vegetable production systems adapt to climate change. Sustainable nutrient management practices support agricultural resilience and lessen the negative effects of climatic variability.

LITERATURE REVIEW

Effect of integrated nutrient management in Solanaceous vegetables

Tomato: INM optimizes tomato cultivation through a blend of organic and chemical fertilizers, microbial inoculants and efficient practices. Growers and the environment all gain from this all surround strategy, which improves tomato output, quality and sustainability. In tomato variety Kashi Amrit, the integrated application of 100% Recommended Dose of Fertilizers (RDF)+*Azotobacter*+Phosphate Solubilizing Bacteria (PSB)+Vesicular Arbuscular Mycorrhizae (VAM) may give the highest fruit production together with favorable fruit set and quality characteristics [6]. According to Singh et al., tomato plants treated with 50% RDF+10 t ha^{-1} Farm Yard Manure (FYM)+5 t ha^{-1} poultry manure+biofertilizer had the highest number of leaves per plant, the most fruits per plant, the longest fruits per plant, the mean fruit weight, the yield per plant, the yield per plot and the highest ascorbic acid content [7]. According to Sepat et al., applying 50% Nitrogen Phosphorus Potassium (NPK)+FYM+*Azotobacter* resulted in values for $plant^{-1}$ height, branches, fruit clusters, fruit size, fruit weight and fruit yield $plant^{-1}$ in tomatoes [8]. By utilizing both organic and inorganic fertilizers in integrated nutrient management, the soil environment is enhanced, the nutrient level is maintained and the perfect conditions are created for the healthy development of tomatoes with large yields [9].

Brinjal: INM maximizes brinjal cultivation by blending organic and chemical fertilizers, biofertilizers and efficient practices. Customized nutrient programs are guided by soil analysis and organic inputs such as farmyard manure and compost are added to the soil to enhance it. Paswan et al., found that the fruit production metrics, such as fruit number per plant, fruit length, fruit diameter, fruit weight and fruit yield per hectare, considerably improved with soil treatments of 100% NPK+25% N through vermicompost [10]. Brinjal output is increased and soil health is maintained with the application of 50 kg nitrogen through urea and 50 kg nitrogen through chicken manure per acre [11]. Under vermicompost at 10 t/ha+75% RDF (NPK), noticeably higher values of yield characteristics were reported, including fruit yield per plot and fruit yield ton per hectare. Under control FYM at 20 t/h+75% RDF, however, noticeably minimum values of yield characteristics were noted [12].

Chilli: The effects of NPK, organic manure and their combination on the development, yield and nutrient absorption of chilli plants were studied by Altaf et al., [13]. The fruit's width, length and weight increased significantly, as did the plant's height at harvest, the number of branches per plant and the number of fruits per plant. In a similar manner, NPK 100%+FYM at 8 tons per hectare increased ascorbic acid concentration and oleoresin production. The yield was increased by using FYM at 8 tons per acre together with NPK 100%. In an experiment on integrated nitrogen management in chillies, Behera et al., sought to ascertain the effects of various combinations of nitrogen sources on chilli production, uptake, quality measures and economics [14]. Due to a 50/50 mixture of urea and vermicompost, T5-50% RDF+50% N *via* vermicompost exhibited the greatest levels of chilli production, including fruit output (14511.4 kg hectare) and nitrogen absorption by fruit (122.31 kg hectare). In terms of chilli quality attributes such oleoresin, capsaicin and ascorbic acid (100 percent RDF), T2 had the greatest B:C ratio.

Effect of integrated nutrient management in Cucurbitaceous vegetables

INM plays an important role in the cultivation of cucurbitaceous vegetables such as cucumbers, pumpkins, water melon, musk melon, bitter gourd, bottle gourd and pointed gourd etc. In an experiment conducted by Singh et al., cucumber plants fertilized with RDF+vermicompost at 5 t ha^{-1}+*Azotobacter* at 5 Kg ha^{-1}+PSB at 5 Kg ha^{-1} demonstrated the highest yield and related traits [15]. This is the best integrated nutrient management approach for protected cucumber cultivation under Punjabi conditions. In soil applications of lime +biofertilizer+vermicompost@5 t ha^{-1}+RDF (100%). Nayak et al., noted the length of the vine, vine girth, number of branches per plant, length of fruit, girth of fruit, single fruit weight, moisture content of fruit, total soluble solid, ascorbic acid and total sugar of pointed gourd [16]. According to Saravaiya et al., a mixture of 50% RDF (60:30:30 NPK kg ha^{-1}) and 10 tons of bio-compost ha^{-1} should be applied to the vine in order to achieve the greater fruit output of pointed gourds (17.93 t/ha) under the INM system [17]. The ascorbic acid, protein content, shelf life, total fruit yield and benefit:cost ratio of bitter gourd plants treated with 100% RDF of NPK+FYM at 5 t ha^{-1}+Biofertilizers at 4 kg ha^{-1} (*Azotobacter* and PSB) have all reached their maximums. According to research by Patel et al., soil treatments of 75% RDN by vermicompost+25% N through urea+*Azotobacter* at 2.5 L ha^{-1}+PSB at 2.5 L ha^{-1} in bitter gourd resulted in increased growth metrics, such as vine length at 45 Days After Sowing (DAS) and at 90 DAS with the number of branches per plant at 90 DAS [18]. Applications of 50% RDF+25% Recommended Dose of Nitrogen (RDN) from Bio-compost+*Azotobacter* 2.5 L ha^{-1}+PSB 2.5 L ha^{-1} were shown to be superior with regard to several growth and yield characteristics of ridge gourd [19]. According to Patel et al., applying 50% RDF and compost to the soil was shown to be the most effective treatment for improving tiny gourd growth and production [20].

Effect of integrated nutrient management in root vegetables

INM significantly impacts the cultivation of root vegetables, such as carrots, potatoes, radishes and beets. A study on the effects of biofertilizers on carrot growth and yield was conducted by Roshni et al., [21]. The experiment used a mix of several biofertilizers and the prescribed NPK level; the factorial Randomized Block Design (RBD) design included three replications. The combination of *Azospirillum*+PSB+*Azotobacter*+VAM generated a superior outcome in terms of growth and yield characteristics, with weight of root (121.99 g), yield per plot (5.12 kg) and yield per hac (194 qt/ha). Such biofertilizers would improve long-term soil health and assist pull in more nutrients for crop development and production when used in conjunction with traditional fertilizers. Shanu et al., conducted an experiment on carrots and the results showed that 25% RDF+50% FYM at 6 t ha^{-1}+50% vermicompost at 3 t ha^{-1}+50% rhizosphere bacteria produced the highest percentage of total soluble solids, ascorbic acid content, carotene content, cortex to core ratio, highest gross return, net return and best benefit cost ratio, while FYM at 12 t ha^{-1} produced the lowest percentage of cracked and forked roots [22]. Basnet et al., found that radish grown with 50% recommended N from chemical fertilizer and 50% N from chicken manure had the highest germination percentage, plant height, root length, root diameter and yield per hectare [23].

Effect of integrated nutrient management in bulb vegetables

Two significant bulbous vegetable crops grown in India are onions and garlic. Higher onion yields were seen when 52.5 kg of nitrogen were applied per hectare using *Azotobacter* biofertilizer. Yadav et al., shown that applications of RDF (50%)+vermicompost (50%) at 90 DAT were associated with the maximum plant height, bulb diameter, neck thickness, bulb length and number of leaves per plant [24]. In a study conducted on onion INM, Brinjh et al., discovered that the RDF 75%+vermicompost 25% produced the highest plant height, whereas the RDF 75%+*Azotobacter* 25% produced the longest leaves, most leaves, thickest necks and most scales. Whereas bulb diameter, length and yield were noted in 75% RDF+25% phosphobacteria [25]. With the application of 100% RDF+vermicompost at 6 t ha^{-1}+sulphur at 45 kg ha^{-1}, which was tested by Kumar et al., the maximum plant height, number of leaves at 120 Days After Planting (DAP), maximum yield $plot^{-1}$, yield ha^{-1}, average fresh weight, average dry weight of bulb, equatorial diameter, polar diameter, average fresh weight of cloves, number of cloves $bulb^{-1}$, length of cloves, neck thickness and dry matter content were recorded in garlic [11]. According to research by Patil et al., applying 120:60:60::N:P:K (RDF) kg/ha+20 t FYM/ha produced the greatest values of all growth parameters, including number of umbels/plant, number of seeds/umbel, weight of seeds/umbel, 1000 seed weight and maximum seed yield [26]. According to Mahanthesh et al., under irrigated circumstances throughout both the kharif and rabi seasons, the plants given *Azospirillum*+100% NPK (125:50:125 kg/ha) recorded the maximum plant height, number of leaves, neck thickness, bulb diameter, bulb weight and bulb yield [27]. Jawadagi et al., used RDF (125:50:125::N:P:K kg/ha)+FYM at 30 t/ha to onions and recorded the maximum leaf length and number of leaves [28]. According to Vachan et al., applying 100% RDF+*Azospirillum*+PSB produced the maximum bulb yield and yield components, including bulb weight, diameter and length, as well as gross and net returns [29]. The application of 60 kg Nitrogen (N)+36 kg Phosphorus pentoxide (P_2O_5)+60 kg Potassium oxide (K_2O) per hectare+vermicompost at 15 t/ha produced the highest plant height, stem

diameter, leaf length, leaf breadth and yield components in garlic [30]. Verma et al., found that while the application of 5 t/ha vermicompost and 60 kg/ha sulphur together was superior in terms of weight of bulb, bulb yield and net returns of garlic, the application of 7.5 t/ha vermicompost and 90 kg/ha sulphur individually produced maximum plant height, number of leaves per plant, chlorophyll content in leaves, fresh weight of leaves, neck thickness, number of cloves per bulb, weight of bulb, bulb diameter and bulb yield [31]. According to research by Damse et al., the application of 75:40:40:40 kg Nitrogen Phosphorus Potassium Sulfur (NPKS)+7.5 t FYM+3.75 t poultry manure per hectare produced the highest bulb yield and benefit-cost ratio, indicating that garlic benefited from the application of lower doses of chemical fertilizers combined with one or two organic sources [32].

Effect of integrated nutrient management in leafy vegetables

Spinach growth and production were shown to be enhanced by using various combinations of nutritional sources. The best method for improving spinach growth and yield was determined to be an integrated application of 50% RDF+50% RDF using VC (vermicompost) [33]. Khadse et al., conducted a research with nine treatment combinations and four replications using a factorial randomized block design [34]. In addition to three vegetables-coriander, fenugreek and spinach-three nitrogen sources are employed in the treatments: 100% nitrogen from urea, 50% nitrogen from FYM+50% nitrogen from urea and 50% nitrogen from FYM+50% nitrogen from vermicompost+biofertilizers. All crop growth parameters were considerably boosted by using 50% nitrogen *via* FYM+50% urea, then 50% nitrogen *via* FYM+50% nitrogen *via* vermicompost+biofertilizers. 50% N *via* FYM+50% N *via* urea was the highest producing INM treatment; it was followed by 50% N *via* FYM+50% N vermicompost+biofertilizers.

Effect of integrated nutrient management in other vegetables

Okra: Applying NPK (100:50:50 kg/ha)+PSB (7.5 kg/ha) will maximize okra's growth and production. In addition to maintaining soil health in okra, the application of N, P and K at 37.5:37.5:37.5 kg per hectare and vermicompost at 1 t per hectare combined with microbial consortia at 3.5 kg per hectare enhanced fruit output. Okra yield was observed to increase using a combination of N, P and K at 50:50:50 kg per hectare with FYM at 10 t per hectare [11]. Maximum plant height and maximum number of leaves were also noted when Azotobactor+PSB+NPK at 120:60:60 was applied. The highest average fruit length was discovered when PSB+NPK at 100:50:50 was used. In terms of the various growth characteristics, treatment with Azotobactor+PSB+NPK at 100:50:50 resulted in yield and quality reports that were considerably higher [35].

DISCUSSION

Integrated Nutrient Management (INM) is a sustainable approach to nutrient management in vegetable crops, offering multifaceted benefits. By combining organic and chemical fertilizers, integrated nutrient management improves soil fertility and structure, optimizing nutrient supply. This approach reduces input costs, enhances crop quality and nutrition and contributes to overall sustainability. By promoting integrated nutrient management practices, it enhances vegetable yields, improves soil health and reduces environmental impact. By minimizing reliance on synthetic inputs, INM contributes to economic viability for growers while preserving natural resources. INM techniques produce ideal growth conditions for vegetable crops by boosting microbial activity, replenishing organic matter and improving soil structure. Therefore, INM practices are significant for a more productive and environmentally friendly vegetable farming sector. Therefore, researchers, policymakers and farmers should promote INM practices for a more productive and environmentally friendly vegetable farming sector [2]. The improvement in production and quality is one of the main impacts of INM on vegetable crops. INM guarantees that crops receive the vital nutrients needed for their growth and development by offering a balanced supply of nutrients. Using both organic and inorganic fertilizers together ensures a steady supply of nutrients for the duration of the growth season. Vegetables with this consistency have better sizes, colors and tastes and their yields are increased. For instance, it has been demonstrated that INM increases fruit size, improves lycopene content and raises the total marketable output in tomato growing [6]. Not only can INM increase crop production and quality, but it also plays a major role in promoting soil health. Aeration, water-holding ability and soil structure are all enhanced by adding more organic matter to the soil through the use of biofertilizers and organic manures. These enhancements encourage the growth of advantageous soil microbes, which are essential to the cycling of nutrients and their availability to plants. Consequently, the soil's long-term fertility is preserved, which lessens the requirement for chemical inputs during subsequent growth seasons.

INM can lessen reliance on chemical fertilizers, which is one of its main benefits. Even while chemical fertilizers are useful, they can be expensive and have unfavorable long-term consequences on the ecosystem and soil health. Without sacrificing the yield of their vegetable crops, farmers can lower the total amount of chemical fertilizers applied by using organic sources of nutrients, such as compost or farmyard manure. In addition to lowering input costs, this decrease in chemical fertilizer use also lessens the environmental risks such as soil deterioration, water pollution and greenhouse gas emissions that come with over-fertilizer application. Moreover, by reducing the negative environmental effects of intensive farming, INM supports sustainable agricultural practices. It promotes the use of environmentally benign and sustainable fertilizer sources, which helps ensure the long-term viability of agricultural systems. Furthermore, INM-grown vegetable crops frequently exhibit greater resistance to biotic and abiotic stressors. Because of the balanced nutrient supply that INM offers, plants are more resilient to environmental challenges like drought and severe temperatures as well as diseases and pests. Farmers may profit greatly from INM in terms of the economy. By lowering the demand for pricey chemical fertilizers, integrating several nutrition sources can save costs. Farmers may lower their total input costs while maintaining or even increasing crop yields by using locally sourced organic manures and biofertilizers. In addition to its environmental advantages, INM's higher profitability makes it a desirable choice for vegetable producers [32].

Future aspects of integrated nutrient management

Future demand for Integrated Nutrient Management (INM) in vegetable production is expected to rise due to the growing importance of sustainability in agriculture. INM offers a holistic approach to nutrient management, improving soil health, reducing environmental impact and encouraging ecosystem resilience. With population growth and climate change challenges, INM is significant for crop resilience and adaptation. The development of INM procedures is driven by customer demands for premium, sustainably produced vegetables. Data-driven decision-making and precision agriculture can maximize fertilizer applications and increase vegetable production output.

CONCLUSION

Integrated Nutrient Management (INM) is a sustainable approach to nutrient management in vegetable crops. It involves combining organic and chemical fertilizers, enhancing soil fertility and structure and optimizing nutrient supply. This approach reduces input costs, improves crop quality and contributes to overall sustainability. By promoting INM practices, it enhances vegetable yields, improves soil health and reduces environmental impact, promoting economic viability and preserving natural resources. By combining bio-fertilizer and organic manure in moderation, INM promotes soil fertility maintenance and sustainable vegetables production. By combining natural and artificial fertilizers, INM ensures ecologically benign and sustainable crop production, making it a significant part of vegetable crop management. INM's capacity to promote soil health is one of its main advantages. INM techniques produce the ideal growth conditions for vegetable crops by boosting microbial activity, replenishing organic matter and improving soil structure.

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REVIEW ARTICLE

An overview of the effect of integrated nutrient management on vegetable crops

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The overview on the effects of Integrated Nutrient Management (INM) on vegetable crops highlights its multifaceted benefits. INM integrates organic and chemical fertilizers, enhancing soil fertility and structure while optimizing nutrient supply to vegetable crops. INM practices are important in vegetable crop production, enhancing the quantity and quality of crops like tomato, brinjal, chilli, radish, carrots, cabbage, cauliflower, broccoli, okra, cucumber pumpkin, melons, gourd and leafy vegetables. By combining natural and inorganic fertilizers with bio-fertilizers, INM methods reduce input costs and enhance crop quality and nutrition. This sustainable approach optimizes nutrient use efficiency, enhances soil health, reduces environmental pollution and contributes to overall sustainability. It is essential for researchers, policymakers and farmers to promote and encourage INM practices for a more productive and environmentally friendly vegetable farming sector. This balanced nutrition leads to increased vegetables yields, improved crop quality and enhanced nutrient use efficiency. Additionally, INM practices promote sustainable soil management, reducing environmental impact and encouraging resilience to abiotic stresses. By minimizing reliance on synthetic inputs, INM contributes to economic viability for growers while preserving natural resources.

Key Words: *Sustainability; Soil health; Natural resources; Vegetables yield*

INTRODUCTION

Integrated Nutrient Management (INM) is pivotal for optimizing vegetable crop productivity while ensuring environmental sustainability. By combining organic and inorganic fertilizers alongside microbial inoculants, INM enhances soil fertility and structure, encouraging strong plant growth and higher yields. By limiting losses and the hazards of environmental contamination associated with synthetic fertilizers, this strategy maximizes nutrient efficiency. As so, it improves soil quality, crop water uptake efficiency and soil health. Furthermore, INM reduces the need for pharmaceutical treatments by encouraging resilience to pests and environmental challenges. Notably, the method improves crop quality, satisfying customer demands for superior, nutrient-dense fruit. In terms of economics, INM maximizes input costs and supports vegetable farming's long-term viability. It is often known that vegetables are an essential dietary supplement for preserving good health and guaranteeing nutritional security. They are significant providers of proteins, carbs, minerals and vitamins. Integrated nutrient management refers to applying both organic and inorganic fertilizers to increase crop yield. Essentially, the INM approach involves applying synthetic fertilizers in addition to agricultural wastes, organic manures, biofertilizers and other biologically related materials in an equivalent ratio [1]. Farmers that cannot afford to utilize chemical fertilization to supply nutrients for any crop can also benefit from the INM approach. In order to boost agricultural output and lessen soil erosion, it also seeks to enhance the biological, mechanical, hydrological and physical qualities of the land [2]. The use of nitrogenous fertilizers excessively or carelessly is detrimental to crop productivity and soil health. Therefore, the application of biofertilizer and organic manure in moderation in addition to chemical fertilizers promotes soil fertility maintenance and lucrative and sustainable crop production [3]. When viewed appropriately, integrated nutrition management can help improve the quantity and caliber of vegetables produced [4]. By combining different nutrient sources, the INM strategy seeks to maximize vegetable crop nutrient usage efficiency. Using both natural and artificial fertilizers in addition to other management techniques, this strategy guarantees crop production that is both ecologically benign and sustainable. INM has drawn a lot of attention lately and is now a significant part of managing vegetable crops [5].

Need of integrated nutrient management in vegetable crops production

Improved soil fertility: In addition to chemical fertilizers, the regular use of organic manures such compost, farmyard manure and green manure helps enhance the fertility, texture and structure of the soil. Better nutrient availability, aeration and water retention result from this, all of which are essential for the growth and development of vegetable crops.

Increased yield and quality: Increased crop yields and better quality characteristics, such vegetable size, color, taste and nutritional content are frequently the outcomes of proper nutrient management using integrated nutrient management. Optimal plant growth and development are supported by balanced nutrition, which raises productivity and produces goods that may be sold.

Enhanced nutrient availability: INM ensures a balanced supply of essential nutrients, including Nitrogen (N), Phosphorus (P), Potassium (K), micronutrients and organic matter. This balanced nutrition promotes vigorous vegetative growth, root development, flowering and fruit set in vegetable crops.

Enhanced soil health: Through the addition of organic matter and the development of beneficial microbial communities, INM methods increase biological activity in the soil. This promotes improved nitrogen cycling, soil health and the long-term sustainability of vegetable cropping systems. It also inhibits soil-borne diseases.

Resistance to abiotic stress: Vegetable crops are more resilient to abiotic stressors like salt, drought and high temperature changes when they are properly nourished, especially when it comes to balanced levels of macro- and micronutrients. Plants that receive proper nutrition are more resilient to environmental shocks and can continue to produce even under difficult circumstances.

Reduced nutrient losses: INM assists in lowering nutrient losses due to volatilization, runoff and leaching by using organic nutrient sources and effective nutrient management techniques. By doing this, the chance of environmental contamination is reduced, nutrient utilization is enhanced and natural resources are preserved.

Improved economic returns: In spite of the possibility of greater upfront expenses associated with organic inputs and management techniques, INM usually yields longer-term advantages. For vegetable producers, more yields,

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better quality, less input needed and more environmental sustainability all translate into higher financial benefits.

Adaptation to climate change: INM techniques can improve crop resilience, water usage efficiency and soil carbon sequestration, all of which can help vegetable production systems adapt to climate change. Sustainable nutrient management practices support agricultural resilience and lessen the negative effects of climatic variability.

LITERATURE REVIEW

Effect of integrated nutrient management in Solanaceous vegetables

Tomato: INM optimizes tomato cultivation through a blend of organic and chemical fertilizers, microbial inoculants and efficient practices. Growers and the environment all gain from this all surround strategy, which improves tomato output, quality and sustainability. In tomato variety Kashi Amrit, the integrated application of 100% Recommended Dose of Fertilizers (RDF)+*Azotobacter*+Phosphate Solubilizing Bacteria (PSB)+Vesicular Arbuscular Mycorrhizae (VAM) may give the highest fruit production together with favorable fruit set and quality characteristics [6]. According to Singh et al., tomato plants treated with 50% RDF+10 t ha^{-1} Farm Yard Manure (FYM)+5 t ha^{-1} poultry manure+biofertilizer had the highest number of leaves per plant, the most fruits per plant, the longest fruits per plant, the mean fruit weight, the yield per plant, the yield per plot and the highest ascorbic acid content [7]. According to Sepat et al., applying 50% Nitrogen Phosphorus Potassium (NPK)+FYM+*Azotobacter* resulted in values for $plant^{-1}$ height, branches, fruit clusters, fruit size, fruit weight and fruit yield $plant^{-1}$ in tomatoes [8]. By utilizing both organic and inorganic fertilizers in integrated nutrient management, the soil environment is enhanced, the nutrient level is maintained and the perfect conditions are created for the healthy development of tomatoes with large yields [9].

Brinjal: INM maximizes brinjal cultivation by blending organic and chemical fertilizers, biofertilizers and efficient practices. Customized nutrient programs are guided by soil analysis and organic inputs such as farmyard manure and compost are added to the soil to enhance it. Paswan et al., found that the fruit production metrics, such as fruit number per plant, fruit length, fruit diameter, fruit weight and fruit yield per hectare, considerably improved with soil treatments of 100% NPK+25% N through vermicompost [10]. Brinjal output is increased and soil health is maintained with the application of 50 kg nitrogen through urea and 50 kg nitrogen through chicken manure per acre [11]. Under vermicompost at 10 t/ha+75% RDF (NPK), noticeably higher values of yield characteristics were reported, including fruit yield per plot and fruit yield ton per hectare. Under control FYM at 20 t/h+75% RDF, however, noticeably minimum values of yield characteristics were noted [12].

Chilli: The effects of NPK, organic manure and their combination on the development, yield and nutrient absorption of chilli plants were studied by Altaf et al., [13]. The fruit's width, length and weight increased significantly, as did the plant's height at harvest, the number of branches per plant and the number of fruits per plant. In a similar manner, NPK 100%+FYM at 8 tons per hectare increased ascorbic acid concentration and oleoresin production. The yield was increased by using FYM at 8 tons per acre together with NPK 100%. In an experiment on integrated nitrogen management in chillies, Behera et al., sought to ascertain the effects of various combinations of nitrogen sources on chilli production, uptake, quality measures and economics [14]. Due to a 50/50 mixture of urea and vermicompost, T5-50% RDF+50% N *via* vermicompost exhibited the greatest levels of chilli production, including fruit output (14511.4 kg hectare) and nitrogen absorption by fruit (122.31 kg hectare). In terms of chilli quality attributes such oleoresin, capsaicin and ascorbic acid (100 percent RDF), T2 had the greatest B:C ratio.

Effect of integrated nutrient management in Cucurbitaceous vegetables

INM plays an important role in the cultivation of cucurbitaceous vegetables such as cucumbers, pumpkins, water melon, musk melon, bitter gourd, bottle gourd and pointed gourd etc. In an experiment conducted by Singh et al., cucumber plants fertilized with RDF+vermicompost at 5 t ha^{-1}+*Azotobacter* at 5 Kg ha^{-1}+PSB at 5 Kg ha^{-1} demonstrated the highest yield and related traits [15]. This is the best integrated nutrient management approach for protected cucumber cultivation under Punjabi conditions. In soil applications of lime +biofertilizer+vermicompost@5 t ha^{-1}+RDF (100%). Nayak et al., noted the length of the vine, vine girth, number of branches per plant, length of fruit, girth of fruit, single fruit weight, moisture content of fruit, total soluble solid, ascorbic acid and total sugar of pointed gourd [16]. According to Saravaiya et al., a mixture of 50% RDF (60:30:30 NPK kg ha^{-1}) and 10 tons of bio-compost ha^{-1} should be applied to the vine in order to achieve the greater fruit output of pointed gourds (17.93 t/ha) under the INM system [17]. The ascorbic acid, protein content, shelf life, total fruit yield and benefit:cost ratio of bitter gourd plants treated with 100% RDF of NPK+FYM at 5 t ha^{-1}+Biofertilizers at 4 kg ha^{-1} (*Azotobacter* and PSB) have all reached their maximums. According to research by Patel et al., soil treatments of 75% RDN by vermicompost+25% N through urea+*Azotobacter* at 2.5 L ha^{-1}+PSB at 2.5 L ha^{-1} in bitter gourd resulted in increased growth metrics, such as vine length at 45 Days After Sowing (DAS) and at 90 DAS with the number of branches per plant at 90 DAS [18]. Applications of 50% RDF+25% Recommended Dose of Nitrogen (RDN) from Bio-compost+*Azotobacter* 2.5 L ha^{-1}+PSB 2.5 L ha^{-1} were shown to be superior with regard to several growth and yield characteristics of ridge gourd [19]. According to Patel et al., applying 50% RDF and compost to the soil was shown to be the most effective treatment for improving tiny gourd growth and production [20].

Effect of integrated nutrient management in root vegetables

INM significantly impacts the cultivation of root vegetables, such as carrots, potatoes, radishes and beets. A study on the effects of biofertilizers on carrot growth and yield was conducted by Roshni et al., [21]. The experiment used a mix of several biofertilizers and the prescribed NPK level; the factorial Randomized Block Design (RBD) design included three replications. The combination of *Azospirillum*+PSB+*Azotobacter*+VAM generated a superior outcome in terms of growth and yield characteristics, with weight of root (121.99 g), yield per plot (5.12 kg) and yield per hac (194 qt/ha). Such biofertilizers would improve long-term soil health and assist pull in more nutrients for crop development and production when used in conjunction with traditional fertilizers. Shanu et al., conducted an experiment on carrots and the results showed that 25% RDF+50% FYM at 6 t ha^{-1}+50% vermicompost at 3 t ha^{-1}+50% rhizosphere bacteria produced the highest percentage of total soluble solids, ascorbic acid content, carotene content, cortex to core ratio, highest gross return, net return and best benefit cost ratio, while FYM at 12 t ha^{-1} produced the lowest percentage of cracked and forked roots [22]. Basnet et al., found that radish grown with 50% recommended N from chemical fertilizer and 50% N from chicken manure had the highest germination percentage, plant height, root length, root diameter and yield per hectare [23].

Effect of integrated nutrient management in bulb vegetables

Two significant bulbous vegetable crops grown in India are onions and garlic. Higher onion yields were seen when 52.5 kg of nitrogen were applied per hectare using *Azotobacter* biofertilizer. Yadav et al., shown that applications of RDF (50%)+vermicompost (50%) at 90 DAT were associated with the maximum plant height, bulb diameter, neck thickness, bulb length and number of leaves per plant [24]. In a study conducted on onion INM, Brinjh et al., discovered that the RDF 75%+vermicompost 25% produced the highest plant height, whereas the RDF 75%+*Azotobacter* 25% produced the longest leaves, most leaves, thickest necks and most scales. Whereas bulb diameter, length and yield were noted in 75% RDF+25% phosphobacteria [25]. With the application of 100% RDF+vermicompost at 6 t ha^{-1}+sulphur at 45 kg ha^{-1}, which was tested by Kumar et al., the maximum plant height, number of leaves at 120 Days After Planting (DAP), maximum yield $plot^{-1}$, yield ha^{-1}, average fresh weight, average dry weight of bulb, equatorial diameter, polar diameter, average fresh weight of cloves, number of cloves $bulb^{-1}$, length of cloves, neck thickness and dry matter content were recorded in garlic [11]. According to research by Patil et al., applying 120:60:60::N:P:K (RDF) kg/ha+20 t FYM/ha produced the greatest values of all growth parameters, including number of umbels/plant, number of seeds/umbel, weight of seeds/umbel, 1000 seed weight and maximum seed yield [26]. According to Mahanthesh et al., under irrigated circumstances throughout both the kharif and rabi seasons, the plants given *Azospirillum*+100% NPK (125:50:125 kg/ha) recorded the maximum plant height, number of leaves, neck thickness, bulb diameter, bulb weight and bulb yield [27]. Jawadagi et al., used RDF (125:50:125::N:P:K kg/ha)+FYM at 30 t/ha to onions and recorded the maximum leaf length and number of leaves [28]. According to Vachan et al., applying 100% RDF+*Azospirillum*+PSB produced the maximum bulb yield and yield components, including bulb weight, diameter and length, as well as gross and net returns [29]. The application of 60 kg Nitrogen (N)+36 kg Phosphorus pentoxide (P_2O_5)+60 kg Potassium oxide (K_2O) per hectare+vermicompost at 15 t/ha produced the highest plant height, stem

diameter, leaf length, leaf breadth and yield components in garlic [30]. Verma et al., found that while the application of 5 t/ha vermicompost and 60 kg/ha sulphur together was superior in terms of weight of bulb, bulb yield and net returns of garlic, the application of 7.5 t/ha vermicompost and 90 kg/ha sulphur individually produced maximum plant height, number of leaves per plant, chlorophyll content in leaves, fresh weight of leaves, neck thickness, number of cloves per bulb, weight of bulb, bulb diameter and bulb yield [31]. According to research by Damse et al., the application of 75:40:40:40 kg Nitrogen Phosphorus Potassium Sulfur (NPKS)+7.5 t FYM+3.75 t poultry manure per hectare produced the highest bulb yield and benefit-cost ratio, indicating that garlic benefited from the application of lower doses of chemical fertilizers combined with one or two organic sources [32].

Effect of integrated nutrient management in leafy vegetables

Spinach growth and production were shown to be enhanced by using various combinations of nutritional sources. The best method for improving spinach growth and yield was determined to be an integrated application of 50% RDF+50% RDF using VC (vermicompost) [33]. Khadse et al., conducted a research with nine treatment combinations and four replications using a factorial randomized block design [34]. In addition to three vegetables-coriander, fenugreek and spinach-three nitrogen sources are employed in the treatments: 100% nitrogen from urea, 50% nitrogen from FYM+50% nitrogen from urea and 50% nitrogen from FYM+50% nitrogen from vermicompost+biofertilizers. All crop growth parameters were considerably boosted by using 50% nitrogen *via* FYM+50% urea, then 50% nitrogen *via* FYM+50% nitrogen *via* vermicompost+biofertilizers. 50% N *via* FYM+50% N *via* urea was the highest producing INM treatment; it was followed by 50% N *via* FYM+50% N vermicompost+biofertilizers.

Effect of integrated nutrient management in other vegetables

Okra: Applying NPK (100:50:50 kg/ha)+PSB (7.5 kg/ha) will maximize okra's growth and production. In addition to maintaining soil health in okra, the application of N, P and K at 37.5:37.5:37.5 kg per hectare and vermicompost at 1 t per hectare combined with microbial consortia at 3.5 kg per hectare enhanced fruit output. Okra yield was observed to increase using a combination of N, P and K at 50:50:50 kg per hectare with FYM at 10 t per hectare [11]. Maximum plant height and maximum number of leaves were also noted when Azotobactor+PSB+NPK at 120:60:60 was applied. The highest average fruit length was discovered when PSB+NPK at 100:50:50 was used. In terms of the various growth characteristics, treatment with Azotobactor+PSB+NPK at 100:50:50 resulted in yield and quality reports that were considerably higher [35].

DISCUSSION

Integrated Nutrient Management (INM) is a sustainable approach to nutrient management in vegetable crops, offering multifaceted benefits. By combining organic and chemical fertilizers, integrated nutrient management improves soil fertility and structure, optimizing nutrient supply. This approach reduces input costs, enhances crop quality and nutrition and contributes to overall sustainability. By promoting integrated nutrient management practices, it enhances vegetable yields, improves soil health and reduces environmental impact. By minimizing reliance on synthetic inputs, INM contributes to economic viability for growers while preserving natural resources. INM techniques produce ideal growth conditions for vegetable crops by boosting microbial activity, replenishing organic matter and improving soil structure. Therefore, INM practices are significant for a more productive and environmentally friendly vegetable farming sector. Therefore, researchers, policymakers and farmers should promote INM practices for a more productive and environmentally friendly vegetable farming sector [2]. The improvement in production and quality is one of the main impacts of INM on vegetable crops. INM guarantees that crops receive the vital nutrients needed for their growth and development by offering a balanced supply of nutrients. Using both organic and inorganic fertilizers together ensures a steady supply of nutrients for the duration of the growth season. Vegetables with this consistency have better sizes, colors and tastes and their yields are increased. For instance, it has been demonstrated that INM increases fruit size, improves lycopene content and raises the total marketable output in tomato growing [6]. Not only can INM increase crop production and quality, but it also plays a major role in promoting soil health. Aeration, water-holding ability and soil structure are all enhanced by adding more organic matter to the soil through the use of biofertilizers and organic manures. These enhancements encourage the growth of advantageous soil microbes, which are essential to the cycling of nutrients and their availability to plants. Consequently, the soil's long-term fertility is preserved, which lessens the requirement for chemical inputs during subsequent growth seasons.

INM can lessen reliance on chemical fertilizers, which is one of its main benefits. Even while chemical fertilizers are useful, they can be expensive and have unfavorable long-term consequences on the ecosystem and soil health. Without sacrificing the yield of their vegetable crops, farmers can lower the total amount of chemical fertilizers applied by using organic sources of nutrients, such as compost or farmyard manure. In addition to lowering input costs, this decrease in chemical fertilizer use also lessens the environmental risks such as soil deterioration, water pollution and greenhouse gas emissions that come with over-fertilizer application. Moreover, by reducing the negative environmental effects of intensive farming, INM supports sustainable agricultural practices. It promotes the use of environmentally benign and sustainable fertilizer sources, which helps ensure the long-term viability of agricultural systems. Furthermore, INM-grown vegetable crops frequently exhibit greater resistance to biotic and abiotic stressors. Because of the balanced nutrient supply that INM offers, plants are more resilient to environmental challenges like drought and severe temperatures as well as diseases and pests. Farmers may profit greatly from INM in terms of the economy. By lowering the demand for pricey chemical fertilizers, integrating several nutrition sources can save costs. Farmers may lower their total input costs while maintaining or even increasing crop yields by using locally sourced organic manures and biofertilizers. In addition to its environmental advantages, INM's higher profitability makes it a desirable choice for vegetable producers [32].

Future aspects of integrated nutrient management

Future demand for Integrated Nutrient Management (INM) in vegetable production is expected to rise due to the growing importance of sustainability in agriculture. INM offers a holistic approach to nutrient management, improving soil health, reducing environmental impact and encouraging ecosystem resilience. With population growth and climate change challenges, INM is significant for crop resilience and adaptation. The development of INM procedures is driven by customer demands for premium, sustainably produced vegetables. Data-driven decision-making and precision agriculture can maximize fertilizer applications and increase vegetable production output.

CONCLUSION

Integrated Nutrient Management (INM) is a sustainable approach to nutrient management in vegetable crops. It involves combining organic and chemical fertilizers, enhancing soil fertility and structure and optimizing nutrient supply. This approach reduces input costs, improves crop quality and contributes to overall sustainability. By promoting INM practices, it enhances vegetable yields, improves soil health and reduces environmental impact, promoting economic viability and preserving natural resources. By combining bio-fertilizer and organic manure in moderation, INM promotes soil fertility maintenance and sustainable vegetables production. By combining natural and artificial fertilizers, INM ensures ecologically benign and sustainable crop production, making it a significant part of vegetable crop management. INM's capacity to promote soil health is one of its main advantages. INM techniques produce the ideal growth conditions for vegetable crops by boosting microbial activity, replenishing organic matter and improving soil structure.

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REVIEW ARTICLE

Innovations and strategies in post-harvest handling and value addition of horticultural produce

Ravi Kishan Soni*, Gajanand Modi

Soni RK, Modi G. Innovations and strategies in post-harvest handling and value addition of horticultural produce. AGBIR.2024;40(4):1206-1209.

Horticultural production is reaching new heights every year, with India being the second-largest vegetable producer globally after China. Despite this, significant postharvest losses occur due to improper management and handling, exacerbating global challenges of food security, hunger, malnutrition and climate change. The United Nations' Sustainable Development Goal 2 aims to reduce food losses by 50% by 2030. This review highlights strategies to enhance the storability of fresh vegetables, including value addition through drying technology, temperature and storage atmosphere control and the use of anti-senescent molecules such as salicylic acid, nitric oxide, 1-methylcyclopropene and methyl jasmonate. In India, horticulture contributes 30% to agricultural Gross Domestic Product (GDP) from 8.5% of the cropped area, with a significant portion of produce being fruits and vegetables. Effective postharvest management and value addition can transform waste into wealth, reduce production costs and optimize biomass utilization. Technologies like drying, dehydration, freezing, fermentation and extraction are essential for recycling and upgrading vegetable market waste. This review provides a comprehensive overview of postharvest losses and potential strategies for reducing losses in vegetables, emphasizing the need for cost-effective technologies tailored to Indian conditions.

Key Words: *Horticulture; Post harvest management; Post harvest losses; Value addition; Biomass*

INTRODUCTION

The horticultural sector holds significant potential for the development of wastelands through well-planned system. Compared to traditional food crops, horticultural crops require comparatively less water, provide higher employment opportunities and are more environment-friendly. From the perspective of nutritional security, fruits and vegetables be prominent due to their potential for value addition, which not only enhances their market value but also contributes substantially to foreign exchange earnings. The horticultural crops are thus not only agricultural products but pivotal commodities in commerce, having gained substantial market potential globally. In the context of the Indian agricultural economy, horticultural crops have a significant role, contributing approximately 30% to the GDP from just 11.73% of the total arable land area. This sector is second only to China in terms of production, making India one of the leading producers of fruits and vegetables globally. In 2012, India's food processing industry was valued at around $ 70 billion, with the country producing 257 million tons of food grains, 75 million tons of fruits and 149 million tons of vegetables. Despite this strong production, India faces significant challenges with post-harvest losses, which are alarmingly high, vary from 30% to 40% for fruits and vegetables. This clearly contrasts with the lower post-harvest losses observed in countries like the United States of America and China, highlighting the urgent need for improved post-harvest management and value addition systems in India [1]. The high rate of post-harvest losses in India can be attributed to various factors, including inadequate infrastructure, inefficient supply chains and insufficient processing facilities. These losses not only reduce the net availability of produce but also represent a significant economic drain, estimated at Rs. 23,000 crores annually. The Swaminathan Committee reported that post-harvest handling accounts for 20%-30% of losses at different stages, including storage, grading, packing, transport and marketing. Furthermore, according to Chadha, India loses about 35%-45% of harvested fruits and vegetables during handling and storage, leading to annual losses of Rs. 40,000 crores [2]. The specific post-harvest losses for various fruits and vegetables further illustrate the severity of the issue: papaya (40%), grapes (27%), banana (20%-28%), citrus (20%-95%), avocado (43%) and apple (14%). Similarly, vegetable losses include onion (25%-40%), garlic (8%-22%), potato (30%-40%), tomato (5%-47%), cabbage and cauliflower (7.08%-25%), chili (4%-35%), radish (3%-5%) and carrot (5%-9%).

Despite these challenges, there are potential opportunities for enhancing the value of horticultural produce through various post-harvest technologies and practices. The diverse group of vegetables produced in India offers significant nutritional and health benefits, including essential vitamins, minerals and dietary fiber. These nutritional benefits are complemented by the presence of various phytochemicals that help in maintaining good health and preventing numerous diseases. Specific vegetable families such as cucurbits (e.g. bottle gourd, bitter gourd, cucumber), solanaceous vegetables (e.g. tomato, brinjal, chili), leguminous vegetables (e.g. Indian bean, French bean, pea), leafy vegetables (e.g. spinach, amaranth, fenugreek), cruciferous vegetables (e.g. cauliflower, cabbage, broccoli) and umbelliferae (e.g. carrot) are powerhouses of these beneficial compounds. To address post-harvest losses and enhance the value addition of horticultural produce, various drying technologies have been explored. Techniques such as hot air-controlled drying, spray drying, freeze drying, infrared drying, superheated steam drying, osmotic dehydration, microwave drying and hybrid drying methods are among the most notable. Freeze drying, although producing the best quality dried produce, has limitations such as longer drying times and higher energy consumption, making it cost-prohibitive for large-scale operations. On the other hand, hot air drying is widely used due to its cost-efficiency and ease of handling, although it may not always preserve the quality of the produce as effectively as freeze drying [3]. Moreover, several innovative post-harvest technologies have been developed to increase the shelf life of fresh produce. These include minimal processing, edible coatings, modified atmosphere packaging, ethylene absorbents, essential oils and hurdle technology. Other advanced methods involve the use of 1-methylcyclopropene, polyamines, salicylic acid, nitric oxide, 6-benzylaminopurine, methyl jasmonate and other anti-senescent molecules, all of which have shown in extending the freshness and shelf life of vegetables [4,5]. The commercial potential of vegetable-based processed products is immense, driven by their taste, health and nutritional benefits. The Indian Council of Agricultural Research (ICAR)-Indian Institute of Vegetable Research (IIVR) at Varanasi has been at the forefront of developing various vegetable-based processed products such as green chili powder, dehydrated okra, bitter gourd chips, instant bottle gourd kheer mix, instant moringa soup mix and instant moringa drink mix. These innovations have been patented and commercialized, providing a viable solution to reduce post-harvest losses and wastage. These developments underscore the need for a greater focus on secondary agriculture to increase employment,

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income and reduce losses, thereby promoting self-reliance and supporting agricultural start-ups [6].

Despite these advancements, a significant gap remains between the gross production of fruits and vegetables and their net availability due to post-harvest losses. The reasons for these losses are multifaceted, encompassing poor facilities, inadequate management, market dysfunctions and occasional carelessness by farmers. Therefore, it is essential to address these issues comprehensively to enhance the efficiency of the supply chain and improve the overall post-harvest management system. The present study aims to explore and discuss the critical issues related to post-harvest management of fruits and vegetables in India, with a particular focus on value addition. By reviewing existing literature and assessing the current state of post-harvest technologies and practices, this study seeks to provide actionable insights and recommendations to reduce post-harvest losses and enhance the value addition of horticultural produce. Such efforts are important for improving the economic viability of horticultural farming, ensuring better nutritional security and contributing to the sustainable development of the agricultural sector in India.

LITERATURE REVIEW

Losses after harvesting

Fruits and vegetables, characterized by their high moisture content, tender texture and high perishability, present a unique set of challenges in post-harvest management. If not handled properly, these highly nutritious products can deteriorate and become rotten within a matter of days or even hours. In the agricultural economy, horticultural crops are not only vital for nutritional security but also generate significant cash income for growers compared to cereals and pulses. The natural respiration process in these crops involves the crisis of food reserves and the aging of these organs, leading to their rapid decline if post-harvest practices are inadequate. Mechanical injuries are a major concern due to the tender texture and high moisture content of fruits and vegetables. Poor handling, unsuitable containers, improper packaging and transportation can easily cause bruising, cutting, breaking and other forms of mechanical injury. These damages significantly reduce the storability and market value of the produce. Physiological deterioration also plays a critical role post-harvest, as the cells of fruits and vegetables remain active and continue their physiological activities. This can lead to disorders caused by mineral deficiencies, temperature injuries or undesirable atmospheric conditions such as high humidity. Enzymatic actions further exacerbate physiological deterioration, resulting in over-ripeness and senescence. The importance of proper harvesting techniques cannot be overstated. Vegetables must be harvested at the correct maturity stage to achieve maximum quality. Harvesting at either pre-maturity or post-maturity stages, coupled with improper handling methods, significantly increases losses. Rough handling during and after harvest often results in mechanical injuries such as bruising, scarring, scuffing, cutting or puncturing the vegetables, thereby lowering their storability and quality. Post-harvest processing typically includes harvesting, sorting, grading and washing. The types of packaging materials used and the methods of transportation play critical roles in determining the extent of post-harvest losses. Farmers often use wooden baskets, gunny bags and plastic crates for packaging, with mini-trucks or lorries being common modes of transport. However, the increased use of corrugated cartons, especially ventilated Corrugated Fiberboard (CFB) boxes, for local distribution has been found to reduce bruising and other mechanical injuries, thereby preserving the quality of the vegetables [7].

Storage conditions also have a significant impact on the longevity of stored vegetables. Optimal storage temperatures can slow down aging, softening, color changes, undesirable metabolic shifts, moisture loss and pathogen-related losses. On-farm storage is particularly critical in remote and inaccessible areas of India, where high perishable vegetables are prone to losses. Proper cold chain management, which includes immediate cooling after harvest and maintenance during transport, is essential. However, the lack of cold storage facilities, coupled with the high cost and energy requirements of refrigeration, poses significant challenges. To address this, low-cost, zero-energy, environmentally friendly cool chambers, such as the Pusa Zero Energy Cool Chamber (Pusa ZECC), have been fabricated from locally available materials and operate on the principle of evaporative cooling. The issue of post-harvest losses is a serious concern for India's agricultural sector, particularly given the highly perishable nature of vegetables. Losses occur due to insufficient methods of harvest, decay, over-ripening, mechanical injury, weight loss, trimming and sprouting. Addressing these aspects is critical for improving the vegetable industry, especially in the context of processing and marketing [8]. Poor planning and lack of market information can lead to overproduction, which in turn results in unsold produce due to inadequate transportation and storage facilities. Additionally, improper preservation methods at home, such as methods of cooking and preparation like peeling, also contribute to these losses. Fruits and vegetables are rich sources of vitamins and minerals essential for human nutrition. However, the loss of these nutritious foods during transit from harvest to consumer represents a significant loss in valuable food quantity. In developing countries, up to 23% of perishable foods spoil due to inadequate cooling. Proper storage temperature management can improve time management and allow for leisurely marketing and consumption. In developed countries, maintaining cold storage temperatures, coupled with relative humidity throughout the entire supply chain from farm to consumer, significantly extends the shelf life of vegetables [9]. Conversely, inadequate storage facilities in developing countries remain a primary cause of post-harvest losses. Transportation presents another significant challenge, especially in the context of globalized food trade. Long-distance transportation with poor refrigerated facilities can lead to substantial losses in both quality and quantity, particularly for fresh produce. Developed countries typically employ refrigerated vehicles for perishable food delivery, whereas inadequate transport and inefficient logistics in developing nations hinder proper preservation. Furthermore, vegetables often suffer from inadequate packaging and careless loading practices, sometimes being haphazardly tossed into vehicles. Effective packaging and refrigerated transport significantly reduce losses and extend shelf life. Studies in Sub-Saharan Africa and South Asia highlight concerning statistics, with 46% of horticultural crops packed in cloth bundles or large sacks, 31% in open baskets and 8% having no packaging at all. At the retail stage, the absence of proper packaging further shortens the shelf life of vegetables, necessitating quick sales. Major challenges include cold chain management, the non-availability of mechanized sorting/grading facilities, the lack of varieties suitable for processing and inefficiencies in the complete value chain of vegetables [10]. The consumption stage, from purchasing to actual consumption is another phase where significant losses occur. Nearly half of household food waste consists of fruits and vegetables. Studies from the Food and Agriculture Organization (FAO) suggest that fruit and vegetable waste constitutes around 39%-40% of total household waste. Reasons for consumer waste vary from over-purchasing and poor planning to inadequate home-storage management. Socio-cultural factors such as gender, lifestyle, income and the availability of home storage facilities also influence the extent of waste [11].

Post-harvest losses in developed nations are often linked to consumer preferences, especially stringent quality standards and safety requirements for fruits and vegetables [12]. These losses are significant not only in quantitative terms but also from the perspective of quality nutrition. Careless harvesting and rough handling of perishable produce can result in bruising and scarring, reducing the quality and market price. Damaged produce also fails to attract international buyers, resulting in economic losses and a tarnished reputation for the exporting country. This degradation in both quantity and quality of food production from harvest to consumption impacts the nutrient/caloric composition, acceptability and edibility of the products. To improve the situation, it is essential to create awareness among growers, farm workers, managers, traders and exporters about the extent of losses being incurred and their economic consequences. These stakeholders need to learn the basic principles of fruit handling and storage. With increasing consumer consciousness about health and nutrition, there is a growing tendency to avoid chemicals and synthetic foods in favor of natural resources. Underutilized fruits such as aonla, bael, jamun, karonda, passion fruit, phalsa, pomegranate, pumpkin, tamarind and wood apple play an essential role in overcoming malnutrition and provide a primary livelihood source for the poor.

Mitigating post-harvest losses in horticulture: Strategies and innovations

The significant issue of post-harvest losses in the vegetable supply chain presents a multifaceted challenge impacting food security, economic stability and the livelihood of farmers globally, particularly in developing countries like India. Effective post-harvest management, encompassing a wide array of activities such as cleaning, washing, sorting, grading, disinfecting, packaging and storage at optimum temperatures, is critical for preserving the edible and nutritional quality of vegetables for extended periods. This approach

not only supports the sustenance of farmers but also enhances the overall efficiency of the food supply chain [13].

Post-harvest management activities

Post-harvest management involves several key processes. Sorting and grading are vital steps where diseased, damaged, over-mature, insect-infested and rotten vegetables are removed, ensuring only high-quality produce reaches consumers. Standardized grading criteria further enhance product consistency, improving market positioning and consumer trust. Washing vegetables eliminates contaminants such as dirt, dust, insects, mold and any residual sprays, thus enhancing their appearance and hygiene. The application of chlorinated water (100-150 ppm) or saltwater (1%-2%) can effectively reduce surface contaminants. Disinfectants like chlorinated water at pH 6.5-7.5 are employed to control inoculum in packing houses during storage [14,15].

Packaging of vegetables

In India, fresh vegetables are typically packaged and transported in perforated plastic crates, gunny bags and bamboo baskets. Softer vegetables often require cushioning with dry grass, banana leaves or paper shreds to prevent damage. Consumer packages may include plastic bags and shrink wraps with or without consumer trays, usually made of foam or plastic. Advanced packaging materials, such as plastic films and waxed liners, provide additional protection. Packaging is generally categorized into consumer units or pre-packaging, transport packaging and unit load packaging or pallets.

DISCUSSION

Challenges with specific vegetables

Broccoli for instance, has a limited shelf life due to its high respiration rates, leading to quick degradation of chlorophyll, flower bud opening, loss of turgidity, off-flavor development and nutritional quality loss. However, the use of Flexfresh™ packaging material, which creates a modified atmosphere during storage at 3°C, has been shown to extend the shelf life of broccoli florets to 49 days. Similarly, capsicum stored in Flexfresh™ expanded polyethylene biopolymer pouches saw increased shelf life and acceptability. Bitter gourd fruits packed in corrugated fiberboard boxes with potassium permanganate sachets exhibited the lowest degradation in fruit quality over an 8-day storage period at room temperature.

Edible coatings

Edible coatings, such as chitosan, cellulose, starch, gums, beeswax and protein-based coatings like gelatin and soy proteins, offer another layer of protection. These coatings reduce moisture loss, slow down respiration, senescence and enzyme activity, preserve natural color, flavor and texture and protect against microbial growth. Application methods include spraying, dipping, smearing or brushing directly onto the vegetable surface, followed by drying to form a protective layer. The efficacy of these coatings depends on various factors, including the materials used, temperature, thickness and type of vegetable. Approved edible coatings enhance shelf life and maintain the quality of various vegetables, including tomatoes, cucumbers and eggplants [16].

1-methylcyclopropene

1-Methylcyclopropene (1-MCP) is an ethylene antagonist that delays natural ripening and aging processes in vegetables. By binding to ethylene receptors, 1-MCP blocks the signaling responsible for ripening, thereby extending the shelf life of produce like cucumbers, tomatoes and peppers. It is recognized for use in over 50 countries and can be applied through various methods, including gaseous treatment, fumigation and aqueous solution dipping.

Value addition

Value addition through drying offers significant opportunities for vegetable preservation. Despite potential innovation and diversification in the vegetable sector, many Small and Medium Enterprises (SMEs) struggle with upscaling, technology access and compliance with international standards. Traditional processing methods, such as drying, can transform perishable vegetables into shelf-stable products, creating new market opportunities and fostering entrepreneurship. For instance, drying techniques can be applied to vegetables like bitter gourd, cauliflower, carrot and broccoli, yielding high-quality, value-added products [1].

Minimal processing

Minimal processing techniques for fresh-cut vegetables are popular due to their fresh-like characteristics, safety and quality. These techniques include cleaning, trimming, slicing, shredding, dicing, sanitizing and packaging. However, processing can cause tissue damage, hasten microbial growth and spoilage, necessitating rigorous sanitation and careful process hygiene. Maintaining a consistent cold chain and employing preservation techniques like chemical preservatives, mild heat treatment and vacuum packaging are significant for minimal processing.

Drying techniques

Drying is a cost-effective method for producing shelf-stable products. Techniques such as solar drying, osmotic dehydration, microwave drying and freeze drying offer various benefits. For instance, osmotic dehydration uses hypertonic solutions for partial moisture removal, resulting in effective drying and rehydration with low energy consumption and high product quality. Microwave drying provides quick and uniform drying, while freeze drying retains maximum quality in the final product but consumes significant energy. These techniques can significantly reduce post-harvest losses and ensure nutritional security [17].

Ready-to-eat convenience products

The demand for ready-to-eat convenience products is growing due to lifestyle changes and increased awareness of health foods. Products like bitter gourd chips and instant bottle gourd kheer mix offer innovative solutions to post-harvest loss while providing consumers with nutritious and convenient options. ICAR-IIVR has developed several vegetable-based convenience products that can be stored for extended periods and reconstituted quickly, addressing both post-harvest losses and consumer needs [1].

The future of post-harvest management and value addition

The future of post-harvest management and value addition in vegetables looks potential for enhancing food security, economic growth and agricultural sustainability. Processing techniques such as freezing, drying and fermentation can transform perishable vegetables into long-lasting products. Investment in research and development, improved infrastructure and innovative processing methods are key to unlocking the full potential of value addition in vegetable crops. These advancements will contribute to economic development, self-reliance and the growing demand for nutritious and high-quality produce.

CONCLUSION

The current scenario underscores significant challenges in post-harvest management and the underutilization of value-addition techniques. However, the potential for innovation and market diversification is vast. Effective post-harvest management and value addition can reduce food wastage, enhance the economic value of vegetables and create new market opportunities. Collaborative efforts in research, technology and policy support are essential to realizing these prospects. By harnessing these opportunities, the agricultural sector can achieve improved sustainability, economic viability for farmers and enriched consumer choices, ensuring a brighter future for vegetable crop management. This introduction sets the stage for a comprehensive exploration of post-harvest management and value addition in vegetables, emphasizing the need for innovative approaches to enhance food security, economic stability and sustainability in agriculture.

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REVIEW ARTICLE

Exploring India's angiosperm diversity: A comprehensive review

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Modi G, Soni RK. Exploring India's angiosperm diversity: A comprehensive review. AGBIR.2024;40(4):1214-1217.

India's remarkable botanical legacy is exemplified by its vast array of angiosperms or flowering plants, thriving within its multifaceted landscapes. This extensive review begins on a thorough exploration of the nation's angiosperm diversity, scrutinizing their distribution, ecological contributions and evolutionary heritage across various ecosystems. By integrating a wealth of existing literature, historical narratives and recent scientific advances, the study provides a nuanced and comprehensive portrayal of India's angiosperm flora.

The review places particular emphasis on endemic species and their conservation status, as well as their integral roles in traditional medicine and cultural practices. Additionally, it investigates the hurdles and prospects for safeguarding India's angiosperm diversity, considering the impacts of habitat degradation, climate change and anthropogenic pressures. By underscoring the critical importance of preserving this botanical treasure trove, the review highlights the pressing need for ongoing research and strong conservation initiatives to protect the ecological balance and cultural heritage of this biodiverse hotspot.

Key Words: *Angiosperm; Biodiversity; Forest; Plant species*

INTRODUCTION

India boasts a rich blend of biological and cultural diversity, standing as one of the 17 mega-biodiverse nations worldwide. Its landscape is inhabited by a plethora of tribal, nomadic, farming and fishing communities, each holding unique nature-based livelihoods and a wealth of traditional knowledge. In contemporary times, the utilization of traditional knowledge has expanded beyond the day-to-day activities of these communities. There is a rising international appetite for natural, herbal and organic products crafted through traditional methods, fueling the growth of industries such as herbal medicine, cosmetics and personal care.

This expanding market demand for bio-resources and associated traditional knowledge presents indigenous and local communities with fresh methods for income generation and economic empowerment. However, the surge in biopiracy and the unprincipled use of traditional knowledge has become a growing concern. The chief factor behind this misappropriation is the unregulated access to traditional knowledge within local communities and the absence of adequate documentation of this invaluable resource [1].

India is a treasure trove of biodiversity, presenting an extraordinary range of ecosystems that span the country's varied topography. The great Himalayan ranges, capped in eternal snow, give way to lush sea-level plains, meandering lowland swamps and complex mangrove networks. This diverse landscape also includes dense tropical rainforests, fertile alluvial plains, vast arid deserts and cold, high-altitude deserts.

The nation's climate is equally diverse, with tropical and subtropical zones characterizing the Indo-Gangetic plains and the Peninsular region, while the northern reaches of the country experience temperate to arctic conditions across the expansive Himalayan region.

These rich biogeographic and climatic conditions cement India's reputation as a global hotspot of biodiversity, emphasizing the critical need for conservation initiatives. Safeguarding this unique ecological heritage is imperative for preserving the wealth of plant and animal life that inhabits these varied ecosystems.

LITERATURE REVIEW

Biogeographically, India is a unique convergence of two major areas-the Palearctic and Indo-Malayan and encompasses five principal forest biomes: Tropical evergreen and semi-evergreen forests, tropical deciduous forests, tropical thorn forests, montane forests and littoral and swamp forests. Reflecting the vast diversity across its landscapes, Balakrishnan delineates the country into eleven phytogeographic zones such as: North-West Himalayas; Indo-Gangetic Plains; Eastern Himalayas (Arunachal Pradesh and Sikkim); Assam (North-Eastern India excluding Arunachal Pradesh and North Bengal); Central India; Arid zone; Northern Western Ghats and northern West Coast; Southern Western Ghats, southern West Coast and Lakshadweep; Deccan; Eastern Ghats and Coromandel coast and Andaman and Nicobar Islands [2]. India, with a geographical expanse of approximately 3,287,263 Km^2, ranks as the world's seventh-largest country. It spans from latitudes 8°4'N to 37°6'N and longitudes 68°7' E to 97°25'E. The nation's forest cover has been estimated at 7,13,789 km^2, constituting 21.71% of its total geographic area. This encompasses 99,779 km^2 of very dense forest, 306,890 km^2 of moderately dense forest, 307,120 km^2 of open forest and 46,539 km^2 of scrubland (Forest Survey of India Report, 2021-22). India's varied topography and climate nurture rich ecological zones and complex forest ecosystems, underscoring the importance of preserving its abundant natural resources and extensive biodiversity.

India is rich in biological diversity largely due to its prevailing varied physical environment, latitude, altitude, geology and climate. Observing the country's rich plant diversity, Hooker commented that 'The Flora of British India is more varied than that of any other country of equal area in the eastern hemisphere, if not on the globe' [3]. The Indian flora represents taxa occurring in different countries including Afghanistan, Bhutan, Bangladesh, China, Nepal, Pakistan, Myanmar, Malaysia, Indonesia, Thailand, Vietnam, Laos and Cambodia. There are even the representatives from African, American, Australian and European countries. Though the geographical area cover of India represents only about 2.4% of the world's total landmass, the country harbours collectively a total of 55,048 taxa belonging to 21,984 angiosperms, 82 gymnosperms, 1314 pteridophytes, 2800 bryophytes, 2989 lichens, 15602 fungi, 9008 algae and 1269 microbes representing approximately 11.4% of total so far recorded species of the world and about 25% of vascular plants that occur in India are endemic to the country [4].

India's floral diversity is predominantly centered around four globally recognized biodiversity hotspots: The Himalayas, Western Ghats and Sri Lanka, Northeast India and the Andaman Islands (Indo-Burma) and the Nicobar Islands (Sundaland). These hotspots are among the 36 recognized worldwide and hold an exceptional concentration of endemic plant species. However, these regions also face significant challenges such as habitat loss and a high incidence of threatened plant species.

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In total, India is home to 4,303 flowering plant taxa across 977 genera in 154 families, deemed to be strictly endemic within the country's current political borders. The endemic flora is dominated by dicotyledons, comprising 3,170 taxa (72%) spread across 723 genera from 127 families. In contrast, monocotyledons contribute 1,133 taxa (26%) from 254 genera in 27 families.

Estimates suggest that approximately 10% of India's flowering plant species are under threat of extinction. This calls for heightened conservation efforts to protect the nation's vast and precious floral heritage, which plays an important role in maintaining ecological balance and supporting local biodiversity.

Northeast India, with its rich botanical heritage, stands as a cradle of flowering plants boasting over 130 species of primitive angiosperms [5]. Moreover, India is recognized as one of the world's 12 Vavilovian Centers of Origin and diversification of cultivated plants, known as the Hindustan Center of Origin of Crop Plants [6]. At least 167 species of significant agri-horticultural crops and 320 species of their wild relatives, spanning 116 genera and 48 families have their roots here [7].

The country's agricultural wealth extends to its diverse landraces, such as the 50,000 to 60,000 varieties of rice, as well as other economically vital crops like wheat, sugarcane, legumes, sesame, eggplant, citrus, banana, mango, jute, ginger, turmeric, pepper, cinnamon and cardamom. This area is a haven for genetic diversity, critical for the resilience and productivity of these staple crops.

Moreover, India's extensive medicinal flora comprises around 3,000 angiosperm species with potential therapeutic qualities. Of these, approximately 1,300 species play a central role in traditional medicinal practices such as Ayurveda, siddha, unani and even modern allopathy. Additionally, the region is home to an array of primitive angiosperm genera, including *Alnus*, *Aspidocarya*, *Betula*, *Decaisnea*, *Euptelea*, *Exbucklandia*, *Haematocarpus*, *Holboellia*, *Houttuynia*, *Magnolia*, *Manglietia*, *Pycnarrhena* and *Tetracentron* [8].

Angiosperms, the most significant group of land plants, encompass over 300,000 species and represent 89.4% of embryophytes [9,10]. Their sudden emergence during the early Cretaceous and subsequent dominance in the later part of that era is considered one of Darwin's "abominable mysteries" [11]. The rapid rise and proliferation of this plant group transformed the planet's landscape and established the structural framework for most terrestrial ecosystems [10,12]. The diversification of angiosperms also facilitated the coevolution of various new organisms in the animal kingdom, including insects and contributed to the diversification of ferns [13,14].

Although there remain debates regarding the origin and lineage of this plant group, their emergence is generally accepted to have occurred in the early cretaceous [15-19].

Angiosperms have been identified across a multitude of geographic locations during the early cretaceous period, but their existence in India during this epoch remains uncertain [19,20]. Sahni reported a vesselless fossil wood designated homoxylon from the Rajmahal region, associating it with vesselless angiosperms [21]. However, Bose et al., reexamined the affinity of homoxylon sahni, situating it within *Bennettitales* and establishing a novel genus, *Sahnioxylon* [22].

In subsequent years, Sharma described Lesqueria Crane and Dilcher, while Banerji identified a fruiting body as sonajoricarpon and a flower-like structure from the Rajmahal formation [23,24]. Banerji drew parallels between sonajoricarpon and the fruits of the extant Fabaceous genus *Butea* Roxb [24]. Despite these early observations suggesting an angiosperm connection, further detailed scrutiny clarified that these fossils were not angiosperms but instead belonged to the gymnosperms [25].

According to Shankar, the Indian subcontinent is home to 34 species of Magnolia, including nine introduced species and hybrids [26]. This richness in biodiversity, both in terms of endemic plants and diverse crop varieties, positions India as a vital global repository of natural heritage, demanding rigorous conservation efforts to safeguard its ecological treasures.

India's political boundaries have shifted several times since the colonial era, affecting the classification and documentation of its rich biodiversity. Sarkar provided an early comprehensive account of endemic genera in India, listing 142 genera, of which four were also found in Bhutan and one extended into southern Tibet [27]. Subsequent reports varied in their listings of endemic genera, with Nayar reporting 147 genera, Ahmedullah reporting 140 and Mitra et al., reporting 121 [28-30]. These reports were based on the distribution information available at the time, but many genera initially considered endemic have since undergone taxonomic revisions with some being merged with parent or allied genera. According to Karthikeyan, there are 2,991 genera found in India, but a critical examination of literature and plant database websites reveals that only 49 genera are truly endemic to India [31]. These 49 genera belong to 22 families and include 80 taxa.

The endemic genera, 40 are confined to Peninsular India, four to the Himalayas and three to the Andaman and Nicobar Islands. The genus *Bentinckia* exhibits a disjunct distribution. *Hardwickia* is common throughout the dry deciduous forests of Peninsular and North India, except for the Northeast.

The families Poaceae, Apiaceae, Asteraceae and Orchidaceae account for approximately 51% of India's generic endemism, with Poaceae alone making up 27%. These genera encompass 34 herbaceous, 12 arborescent and three shrubby species. A total of 165 species (158 angiosperms, 5 gymnosperms and 1 pteridophyte) belonging to 142 genera and 57 families are recorded from the campus of Sangat Sahib Bhai Pheru Khalsa Senior Secondary School Faridkot, Punjab, India from July 2022 to April 2023. Out of 57 families, grass family Poaceae is dominant with represented with 15 species. Ninety-five documented as a weed species, 67 species are cultivated and 3 species both cultivated as well as wild species. Eighty-five species are annual and 80 are perennials.

An initial study in the Subansiri region of the eastern Himalayas uncovered substantial levels of plant endemism. As part of a comprehensive effort to sample different forest types and map biologically rich areas, the study assessed the observed species to determine their endemic status within this significant global biodiversity hotspot. The research included documenting the count of individuals, species, genera and families across both natural and semi-natural forest types. The investigation involved random sampling of 122 plots in different forest types and cataloged 764 plant species, with 59 of them found to be unique to the region. The overall species endemism rate was calculated at 13 per hectare. These 59 endemic species were distributed across 27 families and 46 genera. Interestingly, half of the endemic species were concentrated in just five families: Rubiaceae, Lauraceae, Acanthaceae, *Magnoliac*eae and Rosaceae. Analysis of the stem size class distribution of the most abundant endemic tree species across three primary forest types offered insight into their quantitative status. The study adopted a proportional stratified random sampling method across various vegetation types and utilized satellite remote sensing data to map the region. The discovery of numerous primitive genera and families pointed to a long evolutionary history, underscoring the region's deep-seated botanical heritage and notable species endemism [32].

Rawat et al., conducted a study in the Kandi region of Hoshiarpur, India, documenting an extraordinary collection of 176 plant species spanning 57 distinct families and 133 genera [33]. This remarkable breadth underscores the region's exceptional botanical diversity. Among the species, 175 were angiosperms and one was a gymnosperm, reflecting the overwhelming dominance of flowering plants in the area. Within the angiosperms, dicotyledons constituted a striking 78.3% (137 species across 105 genera), while monocotyledons represented 21.7% (38 species across 27 genera).

DISCUSSION

The study showcased Poaceae as the most prominent family, comprising 30 species across 21 genera. Other significant families included Papilionaceae, Caesalpiniaceae, Euphorbeaceae, Apocynaceae, Acanthaceae and Mimosaceae. Trees emerged as the dominant life form, accounting for 36.9% of the species, followed by shrubs (22.7%), grasses (17.1%), herbs (13.6%), climbers (8.5%) and sedges (1.1%).

The investigation identified 33 plant species from 21 families employed by the local populations of Satrod Khurd and Dabra villages for treating a range of gastrointestinal disorders, including diarrhea and indigestion, as well as skin afflictions. The Fabaceae family emerged as the most prominent, contributing four species, while Lamiaceae followed closely with three species. Other families such as Amaranthaceae, Rutaceae, Meliaceae, Asclepiadaceae, Myrtaceae, Euphorbiaceae and Moraceae each offered two species.

Notable botanical families like Crassulaceae, Cannabaceae, Boraginaceae, Solanaceae, Menispermaceae, Rhamnaceae, Poaceae, Papaveraceae and Combretaceae each provided one species. Important plant components such as leaves, seeds, fruits, bark, roots, twigs and flowers were utilized to treat conditions like diarrhea, dysentery, blood purification and various skin disorders. Several versatile plants, including *Calotropis procera*, *Argemone mexicana*, *Datura metel* and *Azadirachta indica*, exhibited therapeutic efficacy across multiple ailments. The collected data was carefully compared with established literature, peer-reviewed research papers and reputable online sources to ensure its validity and reliability. This comprehensive approach underscored the extreme ethnobotanical knowledge and practices inherent to the region [34].

This comprehensive analysis of the region's forest flora reveals invaluable insights into its rich species diversity, the prominence of particular plant families and the varied composition of life forms. The study highlights the ecological richness and significance of the Kandi region, emphasizing its importance as a center of biodiversity.

In a comprehensive 2023 study conducted by Singh et al., an intriguing assortment of twenty-five angiosperm wild species was identified across 23 genera and 14 families as weeds in crops, gardens and waste areas in Faridkot, Punjab, India [4]. The Asteraceae family emerged as the most prominent, with five distinct species, followed by Poaceae and Solanaceae, each showcasing three species. Brassicaceae, Malvaceae and Scrophulariaceae each presented two species, while the remaining families each held a single species. Of the 23 genera, only two *Solanum* and *Veronica* featured two species apiece, while the rest were monotypic, emphasizing the diverse botanical landscape. Among the 25 species identified, 22 were dicots, highlighting their dominance, while the remaining three were monocots. This study sheds light on the remarkable biodiversity of the region and its dynamic exchange with agricultural and natural ecosystems.

Kaur et al., documented an extraordinary collection of 294 plant species, surround 288 angiosperms, 3 gymnosperms and 3 pteridophytes, across 232 genera and 79 families from Bassi Umar Khan and Atwarapur in the Bhunga block of district Hoshiarpur, Punjab [35]. The Fabaceae family was most prevalent, trailed by notable families such as Poaceae, Asteraceae, Cucurbitaceae and Solanaceae. Of the 294 species, 142 were herbaceous, 66 were trees, 52 were shrubs and 34 were climbers. Among these, 78 species were traditionally utilized in medicinal formulations, representing 26.5% of the overall flora in the study area. Herbs dominated traditional use in various medicinal preparations, followed by trees, shrubs and climbers. The study highlighted that 25 plants were frequently used to treat gastrointestinal disorders, while 16 species were found effective in controlling diabetes. This analysis underscores the region's rich floristic diversity and the extreme traditional knowledge held within the study area.

An extensive study of angiosperm diversity in the Doaba region of Punjab, India, revealed a remarkable total of 464 species across 337 genera and 99 families. Among these species, 88% were dicots, while the remaining 12% were monocots. The data included wild, cultivated and ornamental species. Fabaceae was the most dominant family with 60 species, followed by Asteraceae (33 species), Poaceae (29 species), Euphorbiaceae (20 species), Amaranthaceae (18 species) and Cucurbitaceae and Solanaceae (17 species each).

Out of the total species recorded, 255 were herbs, 65 were shrubs, 85 were trees and 59 were climbers. Additionally, the study identified six species new to the flora of Punjab. This investigation emphasizes the Doaba region's rich angiosperm diversity and underscores the urgent need for its documentation and conservation [36].

The emergence of angiosperms on Earth took place during the Jurassic period. The oldest known angiosperm, *Florigerminis jurassica* Cui et al., (also known as the 'Jurassic flower bud'), dates back approximately 164 million years to the Jurassic period and was unearthed in Inner Mongolia, China, in 2022 [37].

During the early Cretaceous, angiosperms were limited to regions situated between latitudes 45° N and 45° S. These flowering plants gradually began to supplant the non-flowering vegetation of the Jurassic era, establishing a firm presence in the northern hemisphere only in the late Cretaceous period.

Hallier theorized that this plant group originated on a continent located in the southern Pacific Ocean; however, no such continent has ever been found [38]. Nonetheless, researchers like Bailey, Axelrod and Thorne all concurred that the cradle of angiosperms was located in the southern or western Pacific region [39-41]. This extensive area spans from Assam in the west to Australia and the Fiji Islands in the east, surround regions such as Myanmar, southern China, Japan, Malaysia, New Zealand and New Caledonia. While fossil evidence does not specify the precise origin, it does confirm that angiosperms arose within the tropical belt before gradually expanding to higher latitudes.

Within this broad area, known as the Southwest Pacific Basin, primitive angiosperms thrive in abundance. Many early families are isolated to this region and primitive representatives of other families can also be found here.

The paleobotanical record of seed plants remains incomplete. Plants with affinities to ranalian and amentiferous species rank among the oldest of paleobotanical finds. Seed-bearing pteridosperms, possessing fern-like foliage, appear to provide the most plausible evolutionary link to flowering plants, including the seed pod and the cupule that encloses the seed.

According to Cronquist, the subclass Magnoliidae encompasses the most ancient and primitive angiosperms still in existence today [42]. This subclass comprises several time-honored plant families, such as water lilies (Nymphaeaceae), buttercups (Ranunculaceae) and *magnolias* (Magnoliaceae). The Magnoliaceae family showcases distinct primitive traits, including: Large, striking flowers adorned with numerous tepals; abundant spirally arranged free stamens at the base of a cone-like receptacle, which bears numerous spirally arranged free carpels.

As the plant matures, the carpel-bearing section transforms into a woody, cone-like aggregate composed of seed-bearing follicles. Each seed is ensconced within a fleshy, red outer layer known as an aril and is connected to its follicle by a slender, thread-like funiculus.

Additional primitive floral attributes comprise actinomorphic (radially symmetrical) flowers that are perfect (both male and female reproductive structures) and complete (possessing all four floral organs) along with an elongated floral axis or receptacle. These characteristics are prominently displayed in both the flowers and fruits of the Magnolia species, serving as a testament to the ancient lineage of this family.

The Angiosperm Phylogeny Group IV (APG IV) system of classification recognizes the clade Magnoliids as a collection of ancient angiosperms, consisting of four orders: *Canellales*, Laurales, *Magnoliales* and *Piperales*. The *Canellales* order, with families Canellaceae and Winteraceae, is absent in India. However, India hosts a notable presence of other orders: The Laurales order, represented by Hernandiaceae and Lauraceae families; the *Magnoliales* order, surround Myristicaceae, Magnoliaceae and Annonaceae families and the *Piperales* order, which includes the Saururaceae, Piperaceae and Aristolochiaceae families.

CONCLUSION

A key component of India's ecological richness is the diversity of its angiosperms, which are a reflection of the vast range of habitats and climatic conditions found throughout the nation. The critical need to preserve this botanical variety is emphasized in this review, since it is essential to the health of ecosystems and the advancement of fields like environmental science, pharmacology and agriculture. However, there are significant risks to this biodiversity due to the increasing degradation of ecosystems, as well as the consequences of climate change and human activity.

In order to address these issues, a thorough strategy is needed. This entails using cutting-edge genetics, conservation biology and ecosystem management studies, as well as implementing strict conservation laws. Furthermore, educating the local population and implementing sustainable livelihood initiatives might be important in ensuring the protection of these species.

India's angiosperms have enormous potential for upcoming scientific discoveries and advancements. It is imperative that this biodiversity be preserved and used responsibly on a worldwide scale. We can guarantee the preservation of this priceless natural resource for the benefit of both the current and future generations by encouraging cooperation between scientific domains and policy efforts.

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RESEARCH ARTICLE

Analyzing the impact of growth hormones on *in vitro* propagation of *Anacyclus pyrethrum*

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Modi G, Soni RK. Analyzing the impact of growth hormones on *in vitro* propagation of *Anacyclus pyrethrum*. AGBIR.2024;40(4):1226-1228.

Traditional medicine makes use of the wild species *Anacyclus pyrethrum*, also known as *A. pyrethrum*, which belongs to the *Asteraceae* family. In order to commence the cultivation of *Anacyclus pyrethrum*, the study employed 4 to 5 cm immature nodal shoot segments. Antioxidant therapy solved the early issues of leaching and browning when the axillary meristem was activated on MS media with 2.0 mg/L of 6-Benzylaminopurine (BAP), resulting in profuse shoot growth. 0.5 mg/L 6-benzylaminopurine and kinetin amplified cultures were subculturing on Murashige and Skoog (MS) medium. Root induction was achieved on half-strength MS medium with 2.0 mg/L Indole-3-Butyric Acid (IBA) and 0.2% activated charcoal and *ex vitro* rooting with pulse administration of 200.0 mg/L indole-3-butyric acid demonstrated efficacy. The tissue culture approach shown to be reliable and appropriate for large-scale greenhouse cultivation of akarkara plants.

Key Words: *Anacyclus pyrethrum*; *Micropropogation*; *Growth hormone*; *Auxin*

INTRODUCTION

Akarkara is an herbaceous plant from the Compositae (*Asteraceae*) family, is also known as the toothache plant, Brazil cress or para cress. Its unique ability to numb the tongue when its flower buds are consumed has earned it the nickname "toothache plant". Beyond its culinary uses, akarkara is renowned in traditional medicine for its stimulant and diaphoretic properties. The root contains pyrethrin, which is used therapeutically to treat conditions like rheumatism, neuralgia and toothaches. This hardy plant, characterized by its daisy-like flowers and lobed leaves, thrives in arid conditions when grown in well-drained, sandy soil. Although its conservation status is of least concern, sustainable harvesting remains significant.

Akarkara's essential oil and alkaloids, especially spilanthol are known for their virilizing, nervine, heart tonic and antimicrobial properties. Recognized in ayurveda for its diverse medicinal benefits, akarkara is considered an aphrodisiac and a tonic for the male reproductive system. A technique for micropropagation of *Anacyclus pyrethrum* was developed by Singh et al., showing the best response from cotyledonary nodal explants on MS medium with 2.5 µM Kn, yielding an average of 8.88 ± 0.28 shoots per explant [1]. During sub-culturing, the regenerated shoots proliferated and for root induction, elongated shoots exposed to 5 or 10 µM Indole-3-Acetic Acid (IAA) or 5 µM Naphthaleneacetic Acid (NAA) were most successful.

MATERIALS AND METHODS

The study by Singh et al., investigated callogenesis and pellitorine accumulation in *Anacyclus pyrethrum* a medicinal herb [2]. Using cotyledon, hypocotyl and root explants on MS media supplemented with 2,4-Dichlorophenoxyacetic acid (2,4-D), they found that lower 2,4-D concentrations favored root and hypocotyl callus formation, while higher concentrations favored cotyledon callus formation. The weight of harvested calli increased linearly over time. Between days 30 and 75, there was a significant increase in pellitorine accumulation, with the highest amount (94.50 µg/g dry weight) observed in cotyledon calli on day 75. The antioxidant activity of the pellitorine produced from *A. pyrethrum* callus was assessed using the 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) method and an efficient procedure for large-scale production was established [3,4].

Nodal shoot segments of *Anacyclus pyrethrum*, sourced from greenhouse or nursery plants, were used as explants for culture initiation. After surface sterilization with bavistin, antibiotics and $HgCl_2$, the explants were treated with a chilled antioxidant solution. Various concentrations of kinetin or BAP were applied on MS media to promote the production of multiple shoots and the multiplication of axillary buds [5]. Culture multiplication required repetitive transfer and subculturing on media supplemented with ascorbic acid and activated charcoal. Different concentrations of BAP were tested on Murashige and Skoog (MS), Modified Murashige and Skoog (MMS), Woody Plant (WP) and white's media, either alone or in combination with kinetin, IAA or NAA for shoot multiplication [6,7].

In vitro, regenerated shoots were rooted in half-strength MS medium supplemented with various amounts of IBA or NAA and activated charcoal. One method of *ex vitro* rooting involved pulse-treating with IBA, NAA. Subsequently, the plants were transferred to soilrite in bottles for root induction and greenhouse hardening. Once hardened, the plantlets were placed in polybags containing a mixture of vermicompost, black soil and sandy soil [8].

Sections of juvenile nodal shoots, measuring 4 to 5 cm in length, were found suitable for culture initiation. However, explant leaching and browning posed significant challenges to bud break and culture establishment. To mitigate this, the nodal explants were treated with an antioxidant solution for 20 min. On MS medium supplemented with 2.0 mg/L of BAP, 90% of the explants showed bud break and produced 2-3 shoots per node. Conversely, on MS medium with 1.0 mg/L of BAP, the explant's response and shoot development were poor [9]. Higher concentrations (3.0 mg/L) of BAP resulted in bud breaking from the axillary meristem and callus formation at the base. Kinetin treatments also induced bud proliferation, but the growth and number of shoots per explant were considerably lower (Table 1).

TABLE 1

Impact of BAP and kinetin concentrations on bud break and multiple shoot induction from *Anacyclus pyrethrum* nodal explants on MS+additives

Concentration of cytokine (mg/L)	Response (%)	Shoot no. ± SD	Shoot length (cm) ± SD
BAP			
0.5	45	1.35 ± 0.5	0.95 ± 0.28
1	66	1.4 ± 0.55	1.08 ± 0.3
2	95	1.8 ± 0.5	1.2 ± 0.19
3	45	1.5 ± 0.3	1.3 ± 0.25
Kinetin			
0.5	-	-	-

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1	25	0.75 ± 0.51	0.47 ± 0.15
2	55	1.4 ± 0.55	1.2 ± 0.2
3	25	1.2 ± 0.59	1.33 ± 0.18

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; SD: Standard Deviation.

RESULTS AND DISCUSSION

Multiplication and maintenance of cultures

Repeated transfers of the mother plant for two to three cycles resulted in the amplification of *Anacyclus pyrethrum* shoots (Table 2). Shoot multiplication was achieved on MS medium supplemented with 0.5 mg/L of both kinetin and BAP, along with 100 mg/L ascorbic acid and 0.1% activated charcoal. The inclusion of activated charcoal was significant for proper culture growth, as it mitigated the phenol leaching at the culture bases, which otherwise slowed the multiplication rate [10,11]. Approximately 12-13 shoots were regenerated on the shoot multiplication medium with sub culturing every 20 to 25 days (Table 3).

TABLE 2

Production of shoots with repeated transfers of the *Anacyclus pyrethrum* mother explant on MS+0.5 mg/L BAP+additives

Passages	Shoot no. ± SD	Shoot length (cm) ± SD
I	2.6 ± 0.4	1.95 ± 0.4
II	6.9 ± 1.2	3.1 ± 0.3
III	9.1 ± 0.7	2.7 ± 0.3
IV	5.1 ± 0.8	2.1 ± 0.2

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; SD: Standard Deviation.

TABLE 3

Impact of different growth regulator combinations and doses on *Anacyclus pyrethrum* shoot multiplication on MS+additives

Concentration of cytokine (mg/L)	Shoot no. ± SD	Shoots length (cm) ± SD
BAP		
1	3.91 ± 0.91	2.63 ± 0.77
0.5	4.8 ± 1.25	3.31 ± 0.89
0.25	3.31 ± 0.95	1.89 ± 0.47
BAP 0.5+kinetin		
1	7.81 ± 0.69	3.22 ± 0.45
0.5	12.72 ± 0.91	3.91 ± 0.37
0.25	9.86 ± 0.71	1.35 ± 0.37
BAP 0.5+NAA		
1	6.43 ± 0.38	1.6 ± 0.98
0.5	6.71 ± 0.23	1.3 ± 0.65
0.25	7.91 ± 0.75	0.81 ± 0.28
BAP 0.5+IAA		
1	5.89 ± 0.91	1.31 ± 0.47
0.5	7.89 ± 0.79	1.33 ± 0.77
0.25	5.45 ± 0.67	1.29 ± 0.29

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; SD: Standard Deviation; NAA: Naphthaleneacetic Acid; IAA: Indole-3-Acetic Acid.

Using BAP alone at various concentrations on MS medium resulted in the differentiation of only 3-5 shoots. Compared to kinetin, combining NAA or IAA with 0.5 mg/L of BAP was less effective, yielding fewer and shorter shoots. Of all the media types tested, MS medium proved to be the most suitable for culture proliferation. Cultures on MMS medium began to yellow, while those on WP and white's media showed very low rates of shoot growth and multiplication (Table 4).

TABLE 4

Effects of different culture media types on *Anacyclus pyrethrum* shoot multiplication (each medium treated with 0.5 mg/L of BAP and kinetin)

Type of media	Shoot no. ± SD	Shoot length (cm) ± SD
MS	12.7 + 0.86	3.45 + 0.17
MMS	9.71 ± 0.97	2.98 ± 0.18

Note: BAP: 6-Benzylaminopurine; MS: Murashige and Skoog; MMS: Modified Murashige and Skoog; SD: Standard Deviation.

After three to four cycles of maintaining shoot cultures on fresh media, tuber development occurred at the nodes of regenerated shoots. Initially, the nodes formed green, tumor-like structures that eventually turned brown and exhibited root differentiation with abundant root hair development. These tubers later produced shoots with well-developed roots [12-14].

Rooting of *in vitro* produced shoots

Shoots planted on half strength MS medium supplemented with 2.0 mg/L of IBA and 0.2% of activated charcoal were successfully produced *in vitro*. As shown in Table 5, a rooting percentage of 90%-95% was achieved. In contrast, NAA was found to be less effective at inducing roots from *Anacyclus pyrethrum* shoots.

TABLE 5

Impact of auxins (IBA and NAA) on root induction from *Anacyclus pyrethrum* shoots that have been *in vitro* regenerated on half strength MS medium

Concentration in (mg/L)	Response (%)	Root no. ± SD	Root length (cm) ± SD
IBA			
1	81	1.9 ± 0.55	0.9 ± 0.60
1.5	87	2.9 ± 0.45	1.2 ± 0.15
2	93	3.3 ± 0.92	2.7 ± 0.2
3	73	1.9 ± 0.77	1.2 ± 0.2
NAA			
1	61	1.5 ± 0.58	0.96 ± 0.9
1.5	66	1.8 ± 0.77	0.97 ± 0.11
2	73	2.7 ± 0.58	1.7 ± 0.12
5	55	1.9 ± 0.49	0.77 ± 0.71

Note: MS: Murashige and Skoog, SD: Standard Deviation; NAA: Naphthaleneacetic Acid; IBA: Indole-3-Butyric Acid.

Ex vitro rooting of shoots

By pulsing 200 mg/L of IBA over the course of three minutes, shoots grown *in vitro* became rooted. Three to four roots were formed from each of the 90%-95% of the pulse-treated shoots that rooted (Table 6). Moreover, NAA worked well for roots at all concentrations.

TABLE 6

Impact of pulse treatments with IBA or NAA concentrations on the *ex vitro* rooting of *Anacyclus pyrethrum* regenerated shoots

Concentration of auxin	Response (%)	Root no. ± SD	Root length in (cm) ± SD
IBA			
100	65	1.9 ± 0.65	2.5 ± 0.17
200	95	3.1 ± 0.99	3.5 ± 0.14
500	75	1.9 ± 0.49	2.9 ± 0.15
NAA			
100	75	1.6 ± 0.59	1.9 ± 0.15
200	81	2.7 ± 0.69	2.5 ± 0.22
500	62	2.9 ± 0.79	1.5 ± 0.31

Note: SD: Standard Deviation; NAA: Naphthaleneacetic Acid; IBA: Indole-3-Butyric Acid.

Observation

Juvenile nodal shoot segments of *Anacyclus pyrethrum* were effectively used to initiate cultures, leading to the development of multiple shoots through axillary meristem activation on MS medium supplemented with 2.0 mg/L BAP. More than 90% of the nodal explants produced 2-3 shoots [15,16]. Initial issues with leaching and browning were mitigated using antioxidant treatments. Compounds such as ascorbic acid and sodium hydrosulphite were successful in preventing darkening. Other effective agents include cystine, Diethyldithiocarbonate (DTT), sodium bisulphate, citric acid and polyclar [17]. In the plant biotechnology laboratory in Jodhpur, ascorbic acid and citric acid have been utilized to prevent browning and deterioration in cultures of various plant species, including woody plants and trees. Abdelwahd et al., used oxidants and absorbents to reduce the impact of leached phenolics on faba bean regeneration *in vitro* [18].

For *Anacyclus pyrethrum*, nodal explants were cultured and subsequently multiplied through subculturing on MS medium with activated charcoal as an adsorbent and ascorbic acid as an antioxidant. The optimal BAP concentration for shoot multiplication was found to be 0.5 mg/L. Once the axillary meristems are activated, the medium is conditioned for shoot growth, requiring lower levels of cytokinin. This study demonstrated a high rate of shoot multiplication (12-13 shoots per inoculum) for akarkara cultivation.

Root production in adventitious shoots can be influenced by various factors [19]. Heimsch et al., reviewed the organization of the root apical meristem in angiosperms [20]. Micropropagated shoots of *Anacyclus pyrethrum* can be rooted on half-strength MS medium supplemented with 2.0 mg/L IBA and 0.2% activated charcoal. Additionally, a pulse treatment with 200.0 mg/L IBA effectively stimulated rooting *in vitro*. More than 90%-95% of the shoots underwent successful rooting both *in vitro* and *ex vitro*. IBA was identified as the most effective auxin for root induction in akarkara. The micropropagated plants were then acclimated and hardened in a greenhouse. This tissue culture method is proven to be repeatable and suitable for large-scale plant production.

CONCLUSION

Recently sprouted shoots were utilized as explants, with nodal shoot segments proving effective for culture initiation. Multiple shoots were generated by activating the axillary meristem on MS medium supplemented with 2.0 mg/L BAP. Initial issues with browning and leaching were managed through antioxidant treatment. The cultures were subsequently proliferated by subculturing on MS medium enhanced with ascorbic acid and activated charcoal. For optimal shoot multiplication, a lower concentration of BAP (0.5 mg/L) was found to be ideal. Rooting was successfully induced on half-strength MS medium containing 2.0 mg/L IBA and 0.2% activated charcoal. A pulse treatment with 200.0 mg/L IBA resulted in over 90%-95% of the shoots developing roots both *in vitro* and *ex vitro*. The micropropagated akarkara plants were effectively hardened and acclimated in a greenhouse.

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Enhancing Soil Health: A Comprehensive Review of Soil Organic Matter

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INTRODUCTION

Soils are categorized based on their organic matter content as either mineral or organic. Mineral soils, which constitute most of the world's cultivated land, contain between a trace amount and 30 percent organic matter. Organic soils, on the other hand, are naturally rich in organic matter due to climatic conditions. Despite having more than 30 percent organic matter, organic soils are not typically used for vital cropping. This bulletin focuses on the dynamics of organic matter in cropping soils, discussing factors that deplete organic matter and the resulting negative effects. It then explores proactive solutions, reviewing various practices that can increase organic matter content and the subsequent benefits for land and crops. Soil organic matter comprises any material produced by living organisms (plant or animal) that returns to the soil and undergoes decomposition. It includes a range of materials, from intact plant and animal tissues to highly decomposed humus. Most soil organic matter originates from plant tissues, which are composed of 60-90 percent moisture and dry matter containing carbon, oxygen, hydrogen, and small amounts of sulfur, nitrogen, phosphorus, potassium, calcium, and magnesium. Although these nutrients are present in small amounts, they are crucial for soil fertility management. Soil organic matter consists of various components, including an active organic fraction with microorganisms (10-40 percent) and resistant or stable organic matter (40-60 percent), also known as humus. According to Tate (1987) and Theng (1987), soil organic matter can be practically divided into aboveground and belowground fractions. Aboveground organic matter includes plant and animal residues, while belowground organic matter consists of living soil fauna and microflora, partially decomposed plant and animal residues, and humic substances.

The carbon-to-nitrogen (C:N) ratio indicates the type of material and its ease of decomposition, with high C ratio woody materials being more resistant to decomposition than low C

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ratio leafy materials. Although soil organic matter can be divided into different fractions, these fractions are not static end products but reflect a dynamic equilibrium. The total amount and distribution of organic matter in the soil are influenced by soil properties and the annual input of plant and animal residues. In a given soil ecosystem, the rate of decomposition and accumulation of soil organic matter is determined by factors such as soil texture, pH, temperature, moisture, aeration, clay mineralogy, and biological activity. Moreover, soil organic matter itself affects many of these properties.

Organic matter on the soil surface, as raw plant residues, protects the soil from the impacts of rainfall, wind, and sunlight. Removing, incorporating, or burning these residues exposes the soil to adverse climatic effects and deprives soil organisms of their primary energy source. Within the soil, organic matter serves several functions, important for agriculture primarily for two reasons: as a "revolving nutrient fund" and as an agent for improving soil structure, maintaining tilth, and minimizing erosion. As a revolving nutrient fund, organic matter functions in two ways: it stores essential plant nutrients and the stable organic fraction (humus) holds these nutrients in a plant-available form, releasing them upon decomposition. To maintain this nutrient cycling system, the rate of organic matter addition from crop residues, manure, and other sources must equal the rate of decomposition, considering plant uptake and losses from leaching and erosion. If the addition rate is less than the decomposition rate, soil organic matter declines; if higher, it increases. A steady state is achieved when these rates are equal.

In improving soil structure, active and some resistant soil organic components, along with microorganisms (especially fungi), bind soil particles into larger aggregates. Aggregation is crucial for good soil structure, aeration, water infiltration, and resistance to erosion and crusting. Traditionally, soil aggregation has been linked to either total carbon (Matson et al., 1997) or organic carbon levels (Dalal and Mayer, 1986a, 1986b). Recently, techniques have developed to fractionate carbon based on its lability (ease of oxidation), recognizing that these carbon subpools may better indicate soil physical stability and carbon dynamics in agricultural systems (Lefroy, Blair, and Strong, 1993; Blair, Lefroy, and Lisle, 1995; Blair and Crocker, 2000). The labile carbon fraction has been shown to be an indicator of key soil chemical and physical properties, controlling aggregate breakdown in Ferrosols (non-cracking red clays), as measured by the percentage of aggregates smaller than 0.125 mm in the surface crust after simulated rain (Bell et al., 1998, 1999). The resistant or stable

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fraction of soil organic matter primarily contributes to nutrient holding capacity (cation exchange capacity [CEC]) and soil color, decomposing very slowly and thus having less influence on soil fertility than the active organic fraction.

Natural factors influencing the amount of organic matter

The environmental and edaphic factors that control the activity of soil biota, and thus the balance between accumulation and decomposition of organic matter in the soil are described below.

Temperature

Several field studies have shown that temperature is a key factor controlling the rate of decomposition of plant residues. Decomposition normally occurs more rapidly in the tropics than in temperate areas. Ladd and Amato (1985) reported that, despite differences in plant material and climate patterns, the decomposition of leguminous materials in southern Australian sites followed the same pattern as that of ryegrass for sites in Nigeria and the United Kingdom (Jenkinson and Ayanaba, 1977), although the time scales were different. Reaction rates doubled for each increase of 8–9 °C in the mean annual air temperature. The relatively faster rate of decomposition induced by the continuous warmth in the tropics implies that high equilibrium levels of organic matter are difficult to achieve in tropical agro-ecosystems. Hence, large annual rates of organic inputs are needed to maintain an adequate labile soil organic matter pool in cultivated soils. Soils in cooler climates commonly have more organic matter because of slower mineralization (decomposition) rates.

Soil Moisture and Water Saturation

Soil organic matter levels commonly increase as mean annual precipitation increases. Conditions of elevated levels of soil moisture result in greater biomass production, which provides more residues, and thus more potential food for soil biota. Soil biological activity requires air and moisture. Optimal microbial activity occurs at near "field capacity", which is equivalent to 60-percent water-filled pore space (Linn and Doran, 1984). On the other hand, periods of water saturation lead to poor aeration. Most soil organisms need oxygen, and thus a reduction of oxygen in the soil leads to a reduction of the mineralization rate as these organisms become inactive or even die. Some of the transformation processes become anaerobic, which can lead to damage to plant roots caused by waste products or favourable conditions for disease-causing organisms. Continued production and slow decomposition can lead to very large organic matter contents in soils with long periods of water saturation (e.g. peat soils, and tea crops in India). With the exception of the hyperhumid regions, the climates

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of vast areas of the humid, subhumid and semi-arid tropics are characterized by distinct wet and dry seasons. In the wet-dry tropics, large amounts of nitrate often occur in the surface soil during the first part of the rainy season (Greenland, 1958; Mueller-Harvey, Juo and Wild,1989). This accelerated nitrogen mineralization caused by a large increase in microbial activity is the result of the first few rains activating the labile soil organic matter. Farmers who practise "slash and burn" agriculture often choose early planting in order to take advantage of this flush of inorganic N before it is lost through leaching and runoff. In these low-input systems, the amount of nitrate present in the soil during the early part of the rainy season is related closely to the organic matter content of the soil. N availability diminishes during the later part of the rainy season.

Soil Texture

Soil organic matter tends to increase as the clay content increases. This increase depends on two mechanisms. First, bonds between the surface of clay particles and organic matter retard the decomposition process. Second, soils with higher clay content increase the potential for aggregate formation. Macroaggregates physically protect organic matter molecules from further mineralization caused by microbial attack (Rice, 2002). For example, when earthworm casts and the large soil particles they contain are split by the joint action of several factors (climate, plant growth and other organisms), nutrients are released and made available to other components of soil micro-organisms.

Under similar climate conditions, the organic matter content in fine textured (clayey) soils is two to four times that of coarse textured (sandy) soils (Prasad and Power, 1997).

Kaolinite, the main clay mineral in many upland soils in the tropics, has a much smaller specific surface and nutrient exchange capacity than most other clay minerals. Therefore, kaolinitic soils contain considerably fewer clay-humus complexes. In addition, the unprotected labile humic substances are vulnerable to decomposition under appropriate soil moisture conditions. Thus, high levels of organic matter are difficult to maintain in cultivated kaolinitic soils in the wet-dry tropics, because climate and soil conditions favour rapid decomposition. In contrast, organic matter can persist as organo-oxide complexes in soils rich in iron and aluminium oxides. Such properties favour the formation of soil microaggregates, typical of many fine-textured, oxide-rich, high base-status soils in the tropics (Uehara and Gilman, 1981). These soils are known for their low bulk density, high microporosity, and high organic-matter retention under natural vegetation, but also for their high phosphate fixation capacity on the oxides when used for crop production. Current knowledge suggests that whereas organic matter contributes to the dark colour of Vertisols (Coulombe, Dixon and

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Wilding, 1996), it is not considered important in determining either the development, robustness or resilience of structure in these soils (McGarry, 1996). Organic matter levels tend to be low in Vertisols; even as low as 10 g/ kg (Coulombe, Dixon and Wilding, 1996).

Parent material influences organic matter accumulation not only through its effect on soil texture. Soils developed from inherently rich material, such as basalt, are more fertile than soils formed from granitic material, which contains less mineral nutrients. Moreover, the former experience more organic matter accumulation because of abundant vegetative growth.

Topography

Organic matter accumulation is often favoured at the bottom of hills. There are two reasons for this accumulation: conditions are wetter than at mid- or upper-slope positions, and organic matter is transported to the lowest point in the landscape through runoff and erosion. Similarly, soil organic matter levels are higher on northfacing slopes (in the Northern Hemisphere) compared with south-facing slopes (and the other way around in the Southern Hemisphere) because temperatures are lower (Quideau, 2002).

Salinity and Acidity

Salinity, toxicity and extremes in soil pH (acid or alkaline) result in poor biomass production and, thus in reduced additions of organic matter to the soil. For example, pH affects humus formation in two ways: decomposition, and biomass production. In strongly acid or highly alkaline soils, the growing conditions for micro-organisms are poor, resulting in low levels of biological oxidation of organic matter (Primavesi, 1984). Soil acidity also influences the availability of plant nutrients and thus regulates indirectly biomass production and the available food for soil biota. Fungi are less sensitive than bacteria to acid soil conditions.

Vegetation and Biomass Production

The rate of soil organic matter accumulation depends largely on the quantity and quality of organic matter input. Under tropical conditions, applications of readily degradable materials with low C:N ratios, such as green manure and leguminous cover crops, favour decomposition and a short-term increase in the labile nitrogen pool during the growing season. On the other hand, applications of plant materials with both large C:N ratios and lignin contents such as cereal straw and grasses generally favour nutrient immobilization, organic matter accumulation and humus formation, with increased potential for improved soil structure development. Plant constituents such as lignin and other polyphenols retard decomposition. In an experiment in southern Nigeria to compare management effects on soil organic matter accumulation, a three-year fallow with Guinea grass (Panicum maximum),

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which has a high lignin content, maintained a carbon level comparable to that under forest fallow.

Practices that influence the amount of organic matter

The factors leading to reduction in soil organic matter can be grouped as,

- Decrease in biomass production
- Decrease in organic matter supply
- Increased decomposition rates

Decrease in Biomass Production

Replacement of perennial vegetation

A consequence of clearing forest for agriculture is the disappearance of the litter layer, with a consequent reduction in the mbers and variety of soil organisms. While many temperate forest species appear to adapt well to grassland (Curry and Good, 1992), the effects of deforestation in the tropics appear to be more marked. Studies have shown that as soil biodiversity declines, adapted species may take over from the indigenous species and the composition may change drastically. Soil macrofaunal biomass and population density fell to 6 and 17 percent, respectively, in cultivated plots, compared with primary forest in Peruvian Amazonia (Lavelle and Pashanasi, 1989). In Suriname, the number of animals per square metre has fallen to 36 percent and the diversity of species has fallen to 28 percent compared with primary forest (Van der Werff, 1990). The indigenous species have largely disappeared, but adapted species have been available for recolonization. The composition of the macrofaunal community has changed drastically.

Replacement of mixed vegetation with monoculture of crops and pastures

The simplification of vegetation and the disappearance of the litter layer under grassland and monocrop production systems lead to a decrease in faunal diversity. Although root systems (especially of grasses) can be extensive and explore vast areas of soil, the root exudates from one single crop will attract only a few different microbial species. This in turn will affect the predator diversity. The more opportunistic pathogen species will be able to acquire space near the crop and cause harm. Continuous cultivation and grazing also leads to compaction of soil layers, which in turn affects the circulation of air. Anaerobic conditions in the soil stimulate the growth of different micro-organisms, resulting in more pathogenic organisms.

High harvest index

One of the consequences of the green revolution was the replacement of indigenous varieties of species with high-yielding varieties (HYVs). These HYVs often produce more grain and less straw, compared with locally developed varieties; the harvest index of the crop (ratio of

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grain to total plant mass aboveground) is increased. From a production point of view, this is a logical approach. However, this is less desirable from a conservation point of view. Reduced amounts of crop residues remain after harvest for soil cover and organic matter, or for grazing of livestock (which results in manure). Moreover, where animals graze the residues, even less remains for conservation purposes.

Use of bare fallow

Traditionally, a fallow period is used after a period of crop production to give the land some "rest" and to regenerate its original state of productivity. Usually, this is necessary in production systems that have drawn down the nutrient supply and altered the soil biota significantly, such as in slash-and-burn systems or conventional tillage systems. Some farmers use bare fallow to regenerate their lands. However, apart from spontaneous weed growth, this means there is no energy source for the soil biota present on the land. Instead of recovering the soil food web, the soil organic matter is degraded further and the lack of cover can result in severe erosion and runoff when the rains start after the dry season.

DECREASE IN ORGANIC MATTER SUPPLY

Burning of natural vegetation and crop residues

The burning of maize, rice and other crop residues in the field is a common practice. Residues are usually burned to help control insects or diseases or to make fieldwork easier in the following season. Burning destroys the litter layer and so diminishes the amount of organic matter returned to the soil. The organisms that inhabit the surface soil and litter layer are also eliminated. For future decomposition to take place, energy has to be invested first in rebuilding the microbial community before plant nutrients can be released. Similarly, fallow lands and bush are burned before cultivation. This provides a rapid supply of P to stimulate seed germination. However, the associated loss of nutrients, organic matter and soil biological activity has severe long-term consequences.

Overgrazing

There is a tendency throughout the world to overstock grazing land above its carrying capacity. Cows, draught animals and small ruminants graze on communal grazing areas and on roadsides, stream banks and other public land. Overgrazing destroys the most palatable and useful species in the plant mixture and reduces the density of the plant cover, thereby increasing the erosion hazard and reducing the nutritive value and the carrying capacity of the land.

Removal of crop residues

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Many farmers remove residues from the field for use as animal feed and bedding or to make compost. Later, these residues return to contribute to soil fertility as manures or composts. However, residues are sometimes removed from the field and not returned. This removal of plant material impoverishes the soil as it is no longer possible to recycle the plant nutrients present in the residues.

Increased Decomposition Rates

Tillage practices

Tillage is one of the major practices that reduces the organic matter level in the soil. Each time the soil is tilled, it is aerated. As the decomposition of organic matter and the liberation of C are aerobic processes, the oxygen stimulates or speeds up the action of soil microbes, which feed on organic matter. This means that:

When ploughed, the residues are incorporated in the soil together with air and come into contact with many micro-organisms, which accelerates the carbon cycle. The decomposition is faster, resulting in the formation of less stable humus and an increased liberation of CO2 to the atmosphere, and thus a reduction in organic matter.

The residues on the soil surface slow the carbon cycle because they are exposed to fewer micro-organisms and thus wane more slowly, resulting in the production of humus (which is more stable), and liberating less CO2 to the atmosphere.

In terms of short-term organic matter loss, the more a soil is tilled, the more the organic matter is broken down. There are also longer-term losses, attributed to repeated, annual cultivation. Cropping systems that return little residue to the soil accelerate this decline. Many modern cropping systems combine frequent tillage with small amounts of residue, with resultant reductions in the organic matter content of many soils. Historically, manure application (from farm livestock) was common, and it was a dynamic way of maintaining organic matter levels despite repeated cultivation and low residue returns to the soil. Increased on-farm mechanization has reduced livestock numbers, so this source of organic material has been reduced considerably.

Organic matter production and conservation is affected dramatically by conventional tillage, which not only decreases soil organic matter but also increases the potential for erosion by wind and water. The impact occurs in many ways:

1. Ploughing leaves no residues on the soil surface to lessen the impact of rain.
2. Ploughing reduces the quantity of food sources for earthworms and disturbs their burrows and living space, hence populations of certain species decrease drastically. Moreover, reduction of earthworm numbers reduces their impact, through burrowing, in increasing

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porosity and aeration (particularly continuous macropores) and lowers their ability to bury and incorporate plant residues, which facilitates rapid decomposition of organic matter.

3. Tillage by repeated hoeing or discing smoothes the surface and destroys natural soil aggregates and channels that connect the surface with the subsoil, leaving the soil susceptible to erosion. Old root channels and earthworm holes are eliminated, as are the cracks between natural aggregates. The large pores, the ones destroyed by conventional tillage practices, are necessary to conduct water into the soil during rainfall.
4. The development of a plough pan or hoe pan, a layer of compacted soil resulting from smearing action at the bottom of the plough or hoe, may retard both root penetration and water infiltration..
5. Ploughing or discing under dry conditions exacerbates the pulverization of the soil, causing the soil surface to crust more easily, leading to greater water runoff and erosion. This is exacerbated by reduced soil surface roughness, which leaves few depressions for temporary storage of water during intense storms.
6. Increased runoff during rainstorms may also increase the possibility of drought stress later in the season, because water that runs off the field does not infiltrate into the soil to remain available to plants. In some circumstances, imbalances of certain soil organisms can disrupt soil structure and processes, e.g. certain earthworm species in rice fields or pastures.

Drainage

Decomposition of organic matter occurs more slowly in poorly aerated soils, where oxygen is limiting or absent, compared with well-aerated soils. For this reason, organic matter accumulates in wet soil environments. Soil drainage is determined strongly by topography – soils in depressions at the bottom of hills tend to remain wet for extended periods of time because they receive water (and sediments) from upslope. Soils may also have a layer in the subsoil that inhibits drainage, again exacerbating waterlogging and reduction in organic matter decomposition. In a permanently waterlogged soil, one of the major structural parts of plants, lignin, does not decompose at all. The ultimate consequence of extremely wet or swampy conditions is the development of organic (peat or muck) soils, with organic matter contents of more than 30 percent. Where soils are drained artificially for agricultural or other uses, the soil organic matter decomposes rapidly.

Fertilizer and pesticide use

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Initially, the use of fertilizer and pesticides enhances crop development and thus production of biomass (especially important on depleted soils). However, the use of some fertilizers, especially N fertilizers, and pesticides can boost micro-organism activity and thus decomposition of organic matter. The chemicals provide the microorganisms with easy-to-use N components. This is especially important where the C: N ratio of the soil organic matter is high and thus decomposition is slowed by a lack of N.

Practices That Increase Soil Organic Matter

Increased concern about the environmental and economic impacts of conventional crop production has stimulated interest in alternative systems. Central to such systems is the need to promote and maintain soil biological processes and minimize fossil fuel inputs in the form of fertilizers, pesticides and mechanical cultivation. All activities aimed at the increase of organic matter in the soil help in creating a new equilibrium in the agro-ecosystem.

For a system of natural resource management to be balanced, and thus sustainable, it must be able to withstand sharp climatic fluctuations, and to evolve steadily in response to social changes and changes in the costs and availability of inputs of land, labour and knowledge. The more diverse and complex an agricultural system is, the more stable and sustainable it will be in the face of unpredictable vagaries of climate and market. Thus, annual crops, woody perennials and non- woody perennials may be combined in various ways with livestock or trees, or both, in what are now commonly called agro-silvipastoral systems.

Several cases have demonstrated that it is possible to restore organic matter levels in the soil. Activities that promote the accumulation and supply of organic matter, such as the use of cover crops and refraining from burning, and those that reduce decomposition rates, such as reduced and zero tillage, lead to an increase in the organic matter content in the soil (Sampson and Scholes, 2000).

i. Balanced fertilization
ii. Cover crops
iii. Improved vegetative stands
iv. Reforestation and afforestation
v. Agroforestry and alley cropping
vi. Regeneration of natural vegetation

Where the supply of nutrients in the soil is ample, crops are more likely to grow well and produce large amounts of biomass. Fertilizers are needed in those cases where nutrients in the

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soil are lacking and cannot produce healthy crops (FAO, 2000) and sufficient biomass. Most soils in sub-Saharan Africa (SSA) are deficient in P. P is required not only for plant growth but also for N fixation. Unbalanced fertilization, for example mainly with N, may result in more weed competition, higher pest incidence and loss of quality of the product. Unbalanced fertilization eventually leads to unhealthy plants. Therefore, fertilizers should be applied in sufficient quantities and in balanced proportions. The efficiency of fertilizer use will be high where the organic matter content of the soil is also high. In very poor or depleted soils, crops use fertilizer applications inefficiently. When soil organic matter levels are restored, fertilizer can help maintain the revolving fund of nutrients in the soil by increasing crop yields and, consequently, the amount of residues returned to the soil.

Cover crops

Growing cover crops is one of the best practices for improving organic matter levels and, hence, soil quality. The benefits of growing cover crops include:

- They prevent erosion by anchoring soil and lessening the impact of raindrops.
- They add plant material to the soil for organic matter replenishment.
- Some, e.g. rye, bind excess nutrients in the soil and prevent leaching.
- Some, especially leguminous species, e.g. hairy vetch, fix N in the soil for future use.
- Most provide habitat for beneficial insects and other organisms.
- They moderate soil temperatures and, hence, protect soil organisms.

A range of crops can be used as vegetative cover, e.g. grains, legumes and oil crops. All have the potential to provide great benefit to the soil. However, some crops emphasize certain benefits; a useful consideration when planning a rotation scheme. It is important to start the first years with (cover) crops that cover the surface with a large amount of residues that decompose slowly (because of the high C:N ratio). Grasses and cereals are most appropriate for this stage, also because of their intensive rooting system, which improves the soil structure rapidly.

In the following years, when soil health has begun to improve, legumes can be incorporated in the rotation. Leguminous crops enrich the soil with N and their residues decompose rapidly because of their low C:N ratio. Later, when the system is stabilized, it is possible to include cover crops with an economic function, e.g. livestock fodder.

The selection of cover crops should depend on the presence of high levels of lignin and phenolic acids. These give the residues a higher resistance to decomposition and thus

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result in soil protection for a longer period and the production of more stable humus.

The term green manure is often used to indicate the same plant species that are used as cover crops. However, green manure refers specifically to a crop in the rotation grown for incorporation of the non-decomposed vegetative matter in the soil. While this practice is used specifically to add organic matter, this is not the most effective use of organic matter (especially in hot climates) for two reasons:

- Mechanical disturbance of the soil should be avoided as much as possible.
- When biomass is incorporated in the soil all at one time, there is a short period of high microbial activity in decomposing the material. This results in the sudden release of a large quantity of nutrients that cannot be captured by the seedlings ofthe following crop and is thus lost from the system.

In general, the greater the production of green manure or crop biomass, the greater is the microbial, mesofauna and macrofauna population of the soil – from fungi and micro-organisms to earthworms and termites. The dynamics of surface residue decomposition depend *inter alia* on the activity of micro-organisms and also on soil mesofauna and macrofauna. The macrofauna consists mainly of earthworms, beetles, termites, ants, millipedes, spiders, snails and slugs. These organisms help integrate the residues into the soil and improve soil structure, porosity, water infiltration, and through-flow through the creation of burrows, ingestion and secretions.

The natural incorporation of cover-crop and weed residues from the soil surface to deeper layers in the soil by soil macrofauna is a slow process. The activity of micro-organisms is regulated by the activity of the macrofauna, because the latter provide them with food and air through their bioturbation activities. In this way, nutrients are released slowly and can provide the crop with nutrients over a longer period. At the same time, the soil is covered for a long time by the residues and is protected against the impact of rain and sun.

Improved vegetative stands

In many places, low plant densities limit crop yields. Wide plant spacing is often practised as "a way to return power to the soil" or "to give the soil some rest", but in reality it is an indicator that the soil is impoverished. Plant spacing is usually determined by farmers in relation to soil fertility and available water or expected rainfall (unless standard recommendations are enforced by extension). This means that plants are often spaced widely on depleted soils in arid and semi-arid regions with a view to ensuring an adequate provision of plant nutrients and water for all plants.

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However, it is important to maintain the recommended plant spacing in order to optimize biomass production and rooting density and, hence, organic matter for food, moisture retention and habitat for soil organisms. Once the crop is established, reduced sunlight between closer crop rows may also reduce regrowth of weeds.

Planting pits are a way of increasing biomass production and crop yields on severely degraded land in semi-arid conditions. Rainfall is concentrated near the plants, and soil faunal activity and organic matter accumulation are concentrated in the planting pits. Planting pits have been introduced successfully in Zambia as a conservation practice for smallholder farmers, who do not have fertilizers or tractor services available to them.

Agroforestry and alley cropping

Agroforestry is a collective name for land-use systems where woody perennials (trees, shrubs, palms, etc.) are integrated in the farming system (FAO, 1989). Alley cropping is an agroforestry system in which crops are grown between rows of planted woody shrubs or trees. These are pruned during the cropping season to provide green manure and to minimize shading of crops (FAO, 1993). Agroforestry covers a wide range of systems combining food crops, forestry and pasture species in different ways (agro-silviculture, silvipasture, agro-silvipasture and multipurpose forest production). There are two different approaches to agroforestry. One uses agricultural crops or pasture as a transitional means of utilizing the land until forest plantations are fully established. The other is to integrate trees and shrubs permanently into the crop or animal production system, to the benefit of both crop production and land resource protection. Thus, agroforestry encompasses many traditional land-use systems such as home gardens, shifting cultivation and bush fallow systems (FAO, 1989).

Alley cropping can be considered an improved bush fallow system. Small trees or shrubs are planted in cropland in rows, preferably along the contour (even where east–west orientation of the rows may minimize shading of crops). The optimal spacing between rows depends on: slope; soil type and its susceptibility to erosion; rainfall; crop species; and the soil and crop management system (FAO, 1995).

Besides adding organic matter to the system, perennial trees and shrubs recycle plant nutrients from deeper soil layers through their rooting system. Through litter and pruning, these can be used again by annual crops. Probably the most important contribution of perennials in a production system lies in the fact that throughout the whole year their roots excrete root exudates and decaying root cells, which in turn are used as an energy source by

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soil micro- organisms. The food web in the soil is maintained, even during dry seasons when no annual crops are grown. The result is that soil biota are in place to provide the crop with nutrients at the beginning of the next cropping season.

Direct seeding is the easiest and cheapest way of establishing hedgerows around fields or in the fields (alleys). However, emerging seedlings may not be able to compete with weeds without additional care. Therefore, starting plant growth in a nursery and transplanting may be necessary for some species. Other species may be established by cuttings. With good establishment, the plants will be better able to withstand both dry spells and browsing by livestock. Crucial to a successful establishment of the hedgerow is that the selected plants should be tall enough to outgrow the weeds at the time of the first crop harvest.

Reforestation and afforestation

Afforestation means the establishment of a forest on land that has not grown trees recently. It can serve two principal soil and water conservation purposes: protection of erosion-prone areas, and revegetation and rehabilitation of degraded land. Afforestation is specifically used to provide protective cover in vulnerable, steep and mountainous areas. Afforestation helps to replenish timber resources and provide fuelwood and fodder (FAO, 1979).

The establishment of a forest cover under good management is an effective means of increasing organic matter production. However, the land must have the productive capacity to support an appropriate forest type, which differs according to climate, soil, slope and the specific purpose of the forest (timber production, livestock grazing, etc.). Therefore, the choice of species and the selection of an appropriate site are of particular importance for successful afforestation.

The procurement of adequate quantities of good quality seed of the species and provenances (adapted varieties) required is a prerequisite for any afforestation effort. However, it is often difficult to find suitable and reliable sources of such seeds.

A number of species require special pre-treatment of the seed or seedling in order to achieve satisfactory germination and uniform stand. Such treatment may consist of soaking the seed in water for varying lengths of time, alternate souking and drying, scarifying or chipping the seed coat to render it permeable to water, plunging the seed into boiling water or even boiling it for a short time. Some tree seedlings may need a mycorrhizal treatment when planted in soils that are deprived of associated mycorrhizae species as well as rhizobium species (e.g. *Casuarina* in Senegalese sandy soils). The aim is to ensure that

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good numbers of plants germinate and that germination after sowing is both rapid and uniform (FAO, 1974).

Afforestation can be achieved by direct sowing or replanting young plants from a nursery. The main advantage of direct sowing is the reduced cost. However, this is usually much less reliable and is only justified where:

- seed is plentiful and cheap;
- adequate germination under field conditions can be relied on;
- the seedlings send down a deep tap root rapidly and are able to withstand adverse climatic conditions in the time after germination;
- the rate of growth is sufficiently fast to make a prolonged period of tending and weeding unnecessary.

Regeneration of natural vegetation

Regeneration of natural grasslands and forest areas increases biomass production and improves the plant species diversity, resulting in more diverse soil biota and other associated beneficial organisms. Natural regeneration may be more reliable where land is not very productive. In some cases, natural regeneration of a given area may lead to the infestation of plots by weeds. Increasingly, natural vegetation is being recognized for its multipurpose benefits, for example, fuelwood, fibre, biocontrol (e.g. neem) and medicinal species, as well as restoration of soil fertility (*Acacia albida* and other leguminous species) and habitats for various beneficial species (pollinators and natural enemies) as well as wildlife.

Increased Organic Matter Supply

Protection from fire

Burning affects organic matter recycling significantly. Fire destroys almost all organic materials on the land surface except for tree trunks and large branches. In addition, the surface soil is sterilized, loses part of its organic matter, the population of soil microfauna and macrofauna is reduced, and no ready-to-use organic matter is available for rapid restoration of the populations. However, this practice is widely used (e.g. in Africa) in order to enhance pasture regrowth for livestock (using residual P), to control pests and diseases, and even to catch small animals for food.

A specific and difficult case is the burning of sugar cane before harvesting. It has both a technical dimension (CO_2 and greenhouse gas emissions, mechanization of harvest, sugar content, etc.) and a social dimension (manual cutting, source of survival resources

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for poor/landless workers). The damage depends on fire intensity, which is a function of vegetation type and climate conditions and frequency. The costs and benefits of burning and the methods to minimize harmful effects need to be identified with local populations.

Crop residue management

In systems where crop residues are managed well, they:

- Add soil organic matter, which improves the quality of the seedbed and increases the water infiltration and retention capacity of the soil, buffers the pH and facilitates the availability of nutrients;
- Sequester (store) C in the soil;
- Provide nutrients for soil biological activity and plant uptake;
- Capture the rainfall on the surface and thus increase infiltration and the soil moisture content;
- Provide a cover to protect the soil from being eroded;
- Reduce evaporation and avoid desiccation from the soil surface.

Depending on the nature of the following crop, decisions are made as to whether the residues should be distributed evenly over the field or left intact, e.g. where climbing cover crops (e.g. mucuna) use the maize stalks as a trellis.

An even distribution of residues:

(i) Provides homogenous temperature and humidity conditions at sowing time;

(ii) Facilitates even sowing, germination and emergence;

(iii) Minimizes the development of pests and diseases; and

(iv) Reduces the emergence of weeds through allelopathic effects.

The most appropriate method for managing crop residues depends on the purpose of the crop residues and the experience and equipment available to the farmer. Where the aim is to maintain a mulch over the soil for as long as possible, the biomass is best managed using a knife roller, chain or sledge in order to break it down but not kill it. Where the decomposition process should commence immediately in order to release nutrients, the residues should be slashed or mown and some N applied because dry residues have a high C:N ratio. However, in order to avoid nitrate emission, urea should not be broadcast on the surface but injected where possible.

Utilizing forage by grazing rather thanby harvesting

In many places, there is competition for the use of crop residues that can be used as

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fodder, for roofing, artisan handicrafts, etc. Where residues are to be used for animal feed, either the animals graze the residues directly,or they are stall- or kraal-fed.

Applying animal manure or othercarbon-rich wastes

Any application of animal manure, slurry or other carbon-rich wastes, such as coffee-berry pulp, improves the organic matter content of the soil. In some cases, it is better to allow a period of decomposition before application to the field. Any addition of carbon-rich compounds immobilizes available N in the soil temporarily, as micro-organisms need both C and N for their growth and development. Animal manure is usually rich in N, so N immobilization is minimal. Where straw makes up part of the manure, a decomposition period avoids N immobilization in the field.

Compost

Composting can complement certain crop rotations and agroforestry systems. It can be used efficiently in planting pits and nurseries. It is very similar in composition to soil organic matter. It breaks down slowly in the soil and is very good at improving the physical condition of the soil (whereas manure and sludge may break down fairly quickly, releasing a flush of nutrients for plant growth). In many circumstances, it takes time to rejuvenate a poor soil using these practices because the amount of organic material being added is small relative to the mineral proportion of the soil.

Successful composting depends upon the sufficient availability of organic materials, water, manure and "cheap" labour. Where these inputs are guaranteed, composting can be an important method of sustainable and productive agriculture. It has ameliorative effects on soil fertility and physical, chemical and biological soil properties. Well-made compost contains all the nutrients needed by plants. It can be used to maintain and improve soil fertility as well as to regenerate degraded soil. However, materials for compost production may be in short supply and the technology demands high labour inputs for proper compost production and application. Therefore, compost application may be restricted to certain crops and limited application areas, e.g. vegetable production in home gardens

Mulch or permanent soil cover

One way to improve the condition of the soil is to mulch the area requiring amelioration. Mulches are materials placed on the soil surface to protect it against raindrop impact and erosion, and to enhance its fertility (FAO, 1995). Crop residue mulching is a system of maintaining a protective cover of vegetative residues such as straw, maize stalks, palm fronds and stubble on the soil surface.

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Decreased Decomposition Rates

Reduced or zero tillage

Repetitive tillage degrades the soil structure and its potential to hold moisture, reduces the amount of organic matter in the soil, breaks up aggregates, and reduces the population of soil fauna such as earthworms that contribute to nutrient cycling and soil structure. Tillage has become the most common method to control weeds. However, mulching is a more environmentally sound practice than tillage for weed control. The loose soil that results from tilling has less structure than before; the appearance is deceptive. Subsequent traffic or heavy rain soon packs this loosened soil, not only negating the expensive cultivation that produced the loose soil but also culminating in a degraded environment for water entry, seed germination and root growth. Further cultivation is then required to re-loosen the soil; more expense with the same outcome – subsequent repacking and degraded soil structure. This is a typical "downward spiral" of conventional agriculture. Moreover, tillage when the soil is too moist or too dry leads to compaction or pulverization of soil; but farmers may not have the option to wait for optimal conditions.

Severe, accelerated soil erosion and the high costs in terms of labour and energy associated with plough-based methods of seedbed preparation have led to the widespread adoption of no- or zero-tillage systems for cropping in temperate and tropical climates. In no-tillage systems, the crop is sown into a soil left undisturbed since the harvest of the previous crop. Crop residue mulch is maintained and anchored firmly to the ground. Weed control relies on mechanical slashing or cover crops (FAO, 1993). Contact herbicides are also used in some cases.

In reduced- or zero-tillage systems, soil fauna resume their bioturbating activities gradually. These loosen the soil and mix the soil components (also known as biotillage). The additional benefit of the increased soil organic matter and burrowing is the creation of a stable and porous soil structure without expensive, time-consuming and potentially degrading cultivations.

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A NOVEL APPROACH TRANSFORMING AGRICULTURE

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ABSTRACT

Agriculture is a fundamental and steady sector as it generates and supplies raw materials for the food and feed industries. Due to the rising global population, increased nutrient depletion, the need to boost total food grain production, decreasing arable lands, limited water availability, declining soil organic matter, climate change, and various other factors, it is essential to adopt modern technologies like nanotechnology in agricultural sciences. Nanotechnology offers numerous applications across all stages of production, processing, storage, packaging, and transportation of agricultural products. The goal of using nanomaterials in agriculture is to reduce the amount of spread chemicals, minimize nutrient losses in fertilization, and increase yield through improved pest and nutrient management. Key benefits of nanotechnology in agriculture include specific applications like nanofertilizers and nanopesticides, which help in monitoring product and nutrient levels to enhance productivity without contaminating soil and water while providing protection against various insect pests and microbial diseases. Nanotechnology can also act as sensors for monitoring soil quality in agricultural fields, thus maintaining the health of agricultural plants (Prasad et al., 2017). It promises to revolutionize agriculture and the food industry by introducing new techniques such as precision farming, enhancing plants' nutrient absorption, more efficient and targeted use of inputs, disease detection and control, resilience against environmental stresses, and advanced systems for processing, storage, and packaging. Nanoclays and zeolites can increase the efficiency of applied fertilizers and restore soil fertility by releasing fixed nutrients. Nanoherbicides are being developed to tackle perennial weed management and deplete weed seed banks. Environmental pollution levels can be swiftly assessed using nano smart dust and gas sensors (Shaimaa and Mostafa, 2015).

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Nanotechnology in Agriculture

Nanotechnology is an interdisciplinary field that spans various applied sciences, including chemistry, physics, biology, medicine, and engineering. It involves controlling the structure of matter at the nanometer scale to create materials with unique properties. Nanotechnology, essentially the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures, produces materials and devices with new or significantly different properties. The term "Nano" is derived from the Greek word "nanos" meaning 'dwarf'. "Nanotechnology" primarily involves processing materials by one atom or molecule at a time.

Nanoparticles (NPs)

Nanoparticles, whether natural or manufactured, have at least one dimension in the range of 1−100 nm. A nanometer is one billionth of a meter. The term "nano" refers to a size scale between 1 nm and 100 nm, involving the development or modification of materials or devices within that size range. Nanoemulsions, carbon nanotubes, quantum dots, nanorods, and nano-encapsulation are examples of nanomaterials. These materials' properties significantly differ from others due to increased relative surface area and quantum effects. Important properties of nanoparticles include morphology, hydrophobicity, solubility, surface area, reactive oxygen species (ROS) capacity, and dispersion/aggregation (Somasundaran et al., 2010).

Potential Applications in Agriculture

Nanotechnology has the potential to transform the agricultural and food industries by introducing new tools for molecular disease treatment, rapid disease detection, and enhancing plants' nutrient absorption. Smart sensors and delivery systems will help the agricultural industry combat viruses and other crop pathogens. Nano-structured catalysts will increase the efficiency of pesticides and herbicides, allowing for lower doses. Nanotechnology will also indirectly protect the environment through renewable energy sources and pollution-reducing filters or catalysts. Nanofertilizers and nanopesticides improve the efficiency of agricultural inputs and conserve natural resources. For instance, the Allosperse delivery system enhances the efficiency of pesticide application. Nano sensors in precision farming and nanomaterials for soil and water conservation, like Geohumus and NanoClay, help utilize natural resources efficiently. Production

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of nanomaterials can manage agricultural waste effectively, such as the production of nanocellulose from agricultural residues by CRICOT India.

Applications in Various Agricultural Fields

Nanotechnology has applications in numerous scientific fields, including agriculture, food technology, crop improvement, seed technology, precision farming, balanced crop nutrition, plant disease diagnosis, weed management, water management, biosensors, and pest management. It is predicted that nanotechnology will transform the entire food industry, changing how food is produced, processed, packaged, transported, and consumed. Controlled Environment Agriculture (CEA) technology provides an excellent platform for introducing nanotechnology into agriculture. Nanotechnological devices for CEA can significantly improve growers' ability to determine the best harvest time, crop vitality, and food security issues (Allah, 2012).

Precision Farming

Precision farming aims to maximize crop yields while minimizing inputs such as fertilizers, pesticides, and herbicides by monitoring environmental variables and applying targeted actions. This method uses computers, global satellite positioning systems, and remote sensing devices to measure localized environmental conditions, determining whether crops are growing efficiently or identifying specific problems. Using centralized data, seeding, fertilizer, chemical, and water use can be fine-tuned to lower production costs and potentially increase production. Although not yet fully implemented, nanotechnology-enabled devices, such as autonomous sensors linked to GPS for real-time monitoring, will significantly impact future precision farming. These nanosensors can monitor soil conditions and crop growth, allowing an earlier response to environmental changes. For example, carbon nanotubes or nano-cantilevers can trap and measure individual proteins or molecules, and nanoparticles can trigger electrical or chemical signals in the presence of contaminants (Tiju and Morrison, 2006).

Nano Sensors

Nanotechnology applications are being developed to improve soil fertility and crop production. Nano-sensors can determine the optimal harvest time, detect crop health, and identify microbial

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or chemical contamination. They can also monitor crop and animal health and remove soil contaminants using magnetic nanoparticles. "Lab on a chip" technology could significantly impact developing nations by providing detailed analysis and monitoring capabilities.

Nanofertilizers

In recent years, nanofertilizers have become available in the market, though agricultural fertilizers are not yet widely produced by major chemical companies. Nanofertilizers may contain nano zinc, silica, iron, titanium dioxide, and other elements, promoting controlled release and improving quality. Studies on the uptake, biological fate, and toxicity of several metal oxide NPs have been conducted to enhance agricultural production (Zhang et al., 2016).

Nanoherbicides

Developing target-specific herbicide molecules encapsulated with nanoparticles aims to target weed roots, inhibiting their growth and ultimately killing them. This approach can address issues like herbicide resistance and reduce the need for multiple herbicide applications. Nanoherbicides can also ensure controlled release, improving weed management even in rain-fed areas where soil moisture is insufficient (Chinnamuthu and Kokiladevi, 2007).

Nanopesticides

Nanopesticides, encapsulated in nanoparticles, offer slow-release properties with enhanced solubility, specificity, permeability, and stability, reducing pesticide dosage and human exposure. This environmentally friendly approach to crop protection minimizes negative impacts on ecosystems (Nuruzzaman et al., 2016). Companies like Syngenta have developed products such as Karate ZEON and Subdue MAXX, which utilize nanoscale emulsions for effective pest control (Kookana et al., 2014).

Applications in Agronomy

Precision agriculture, aided by nano sensors, optimizes the use of fertilizers and chemical pesticides, improving safety and economic efficiency. Nano sensors enable precise farm management, reporting plants' needs timely and ensuring optimal input use. Nanomaterials and GPS with satellite imaging can remotely detect crop pests or stress, allowing for automatic

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adjustment of pesticide applications or irrigation levels. Slow-release fertilizers, like those using zeolites, ensure nutrients are released at a slower rate, minimizing waste and environmental pollution. Nanocomposites containing N, P, K, micronutrients, and amino acids can increase nutrient uptake and utilization by crops (Liu et al., 2006).

Seeds imbibed with nano-encapsulations, termed Smart Seeds, can reduce seed rates and improve crop performance. Smart Seeds can be programmed to germinate when adequate moisture is available, aiding in reforestation efforts. Coating seeds with nano membranes ensures germination at the right time, while magnetic particles detect moisture content during storage, reducing damage. Bio-analytical nano sensors can determine seed aging, enhancing seed quality and germination (Siddiqui and Al-Whaibi, 2014).

Conclusion

The extensive use of agrochemicals to boost agricultural production has polluted topsoil, groundwater, and food. While increasing agricultural productivity is essential, new approaches are needed to mitigate environmental damage. Nanotechnology offers promising solutions, including the delivery of pesticides, biopesticides, fertilizers, and genetic material for plant transformation. Nanomaterials can reduce dosage and ensure controlled slow delivery, stabilizing biocontrol preparations and minimizing environmental hazards. Nanotechnology's unique properties have led to the development of nanosensors capable of detecting pathogens at extremely low levels. These tools can also degrade persistent chemicals into harmless components, addressing urgent environmental protection and pollution issues. By employing nanotechnology, agricultural technology can streamline current practices and provide powerful tools for environmental detection, sensing, and remediation.

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Carbon Sequestration: Techniques and Importance for Climate Mitigation

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Abstract

Carbon sequestration is the process of removing carbon from the atmosphere and depositing it in reservoirs. Basically it is the process of capturing of atmospheric carbon dioxide and storing it to mitigate global warming and climate change. This storage is also known as carbon pools. Carbon pool refers to a system or mechanism which has the capacity to to accumulate or release. It can be natural or human induced. Examples are forest biomass, wood products, soils, and the atmosphere. Carbon pools in a forest are a complex mix of live and dead organic matter and minerals. Human induced carbon pools are geological storage of carbon dioxide.

Human induced carbon pools are characterized with carbon capture and storage (CCS) technology. Carbon capture and storage is a combination of technologies and techniques that enable the capture of CO_2 from fuel combustion or industrial processes. Then transportation of CO2 is being done through pipelines, CO_2 is stored underground in depleted oil and gas fields and deep saline formations. CCS can, therefore, have a unique and imperative role to play in a sustainable low-carbon economy.

Keywords: Global Warming, Climate Change, Carbon Sequestration; CCS Technology

Introduction

Earth is getting more and more warmer than ever, reason is human activities. Human activities have caused an imbalance in natural carbon cycle, consequently greenhouse effect and global warming came into being. When fossil fuels are burnt for transportation, heating, cooking, electricity, and manufacturing, we are



effectively realizing more carbon into the atmosphere. As a result we are proceeding on the path of global warming and climate change.

Global warming and climate change refers to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused primarily by increases in "greenhouse" gases such as carbon dioxide (CO_2). Climate change is as global threat that needs urgent action from global community. All countries will be affected by climate change and its impacts, particularly developing countries. If temperature is taken as an climate change indicator. It has been found that earth's average temperature has risen by 1.4°F (0.72°C) over the past century. It is projected that it will further likely to rise another 2 to 11.5°F over next century (NCAR, 2014). Therefore it is important to understand carbon cycle, climate change and how climate can be mitigated.

Carbon cycle

Carbon cycle refers to the movement of carbon, in its different forms, between the biosphere, atmosphere, oceans and geosphere. **(i) Carbon exchange between atmosphere and vegetation-** Plants adsorb CO_2 from the atmosphere during photosynthesis, and release CO_2 back in to the atmosphere during respiration. Another major exchange of CO2 occurs between the oceans and the atmosphere. The dissolved CO2 in the oceans is used by marine biota in photosynthesis. **(ii) Burning of Fossil Fuels-** Other important processes is fossil fuel burning. In fossil fuel burning, coal, oil, natural gas, and gasoline are consumed by industry, power plants, and automobiles. In this process carbon directly goes to the atmosphere from its source point. **(iii) Change in Land Use and Land Cover-** Changing land use also affect carbon cycle in broad term which include essential human activities e.g. agriculture, deforestation, transportation activities etc. (ETEGCC, 2004). In modern world alterations in land use and land cover and ever increasing usage of energy for the purpose of development is the focal reasons for global warming and climate change.

Climate change

Global warming and climate change refers to an increase in average global temperatures over a very long period time. As discussed in carbon cycle, natural events and human activities are believed to be contributing to an increase in

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average global temperatures. This is caused primarily by increases in "greenhouse" gases such as Carbon Dioxide (CO_2) (Shah, 2013). Small changes in the average temperature of earth so far, can transform into large in coming hundred years. Moreover these climatic changes will have great potential to create negative impacts on environment and mankind. Therefore it is essential to mitigate climate change for advance minimization of its dangerous impacts. Current evidence suggests that to avoid the worst impacts of climate change, we should aim to limit the global average temperature rise to 2°C (35.6°F), not beyond that. This requires to undertake immediate reduction in global greenhouse gas emission in all the sectors.

Indicators for Climate Change

There are several indicators on the basis of which climate change can be measured. These indicators are as following:

Table 1. Indicators for Climate Change

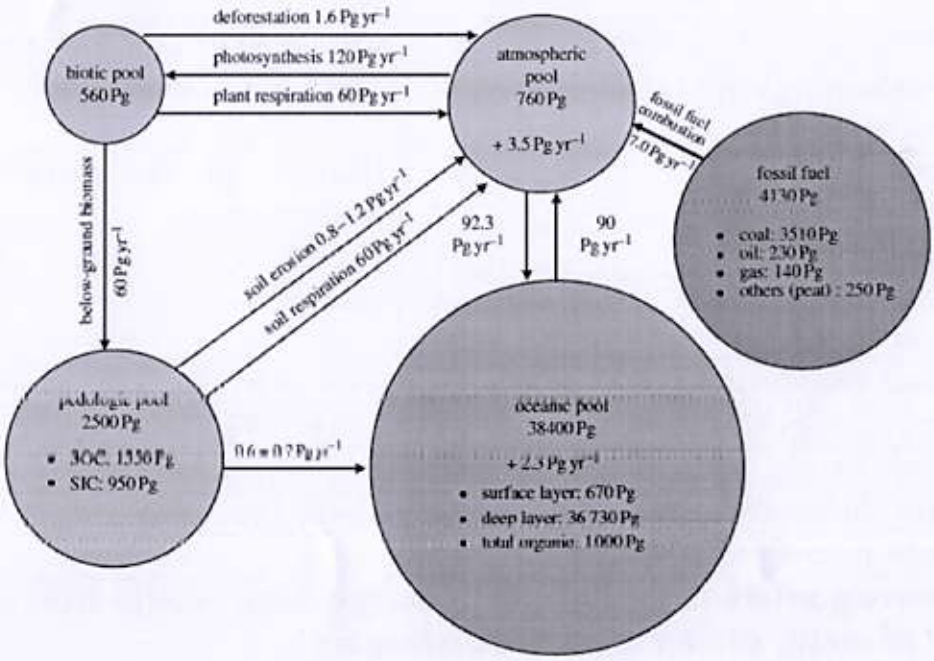
1.	Global green house gas emission	11.	Change in precipitation pattern
2.	Atmospheric concentration of green house gases	12.	Tropical Cyclonic activities
3.	Change in sea level	13.	Increase in the occurrence of extreme events
4.	Change in ocean heat	14.	Change in arctic sea ice
5.	Change in sea surface temperature	15.	Glaciers melting
6.	Change in ocean acidity	16.	Change in length of seasons
7.	Submergence of land into sea	17.	Length of growing season
8.	Climate forcing	18.	Bird wintering ranges
9.	Change in snowfall pattern	19.	Heat related deaths
10.	Change in temperature pattern		

"Climate forcing refers to the amount of energy earth receive from sun and the amount of energy earth radiate back into space

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All extra carbon dioxide in the atmosphere is increasing overall temperature of earth on day to day basis, causing global warming. It is changing climate in unpredictable ways, from floods and hurricanes to heat wave and droughts. To try and reduce the risk of global warming and extreme weather events. It is required to reduce the amount of how much fossil fuel we are burning. This isn't an easy process. In the 1997 Kyoto Protocol, it was decided that carbon emission in thw atmosphere will be reduced by 5% below 1990 levels between 2008 and 2012. Several measures can be found out to reduce from atmosphere and thus to reduce adverse impacts of climate change. One of the measure is carbon sequestration, which is cheap and simple as well as costly and complex. That is natural carbon sequestration and geological carbon sequestration.

Carbon sequestration: - Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide to mitigate global warming and to avoid dangerous impacts of climate change. In other words, it also refers to the process of removing carbon from the atmosphere and depositing it in a reservoir. This storage is also known as carbon pools. Carbon pool refers to a system or mechanism which has the capacity to accumulate or release. Examples are forest biomass, wood products, soils, and the atmosphere.



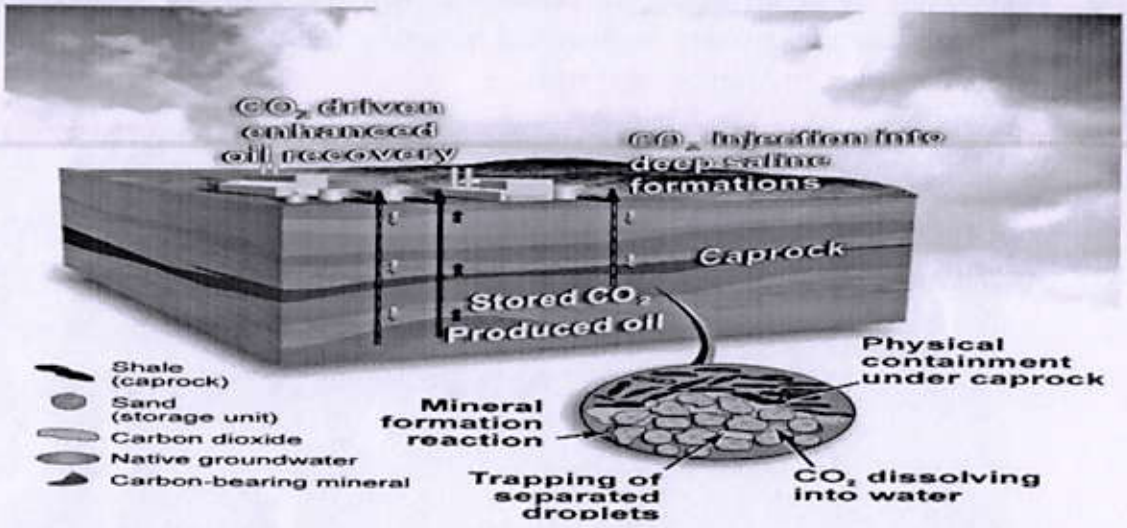
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Figure 1. Principal global C pools and fluxes between them. The data on C pools among major reservoirs are from Batjes (1996), Falkowski *et al.* (2000) and Pacala & Socolow (2004), and the data on fluxes are from IPCC (2001).

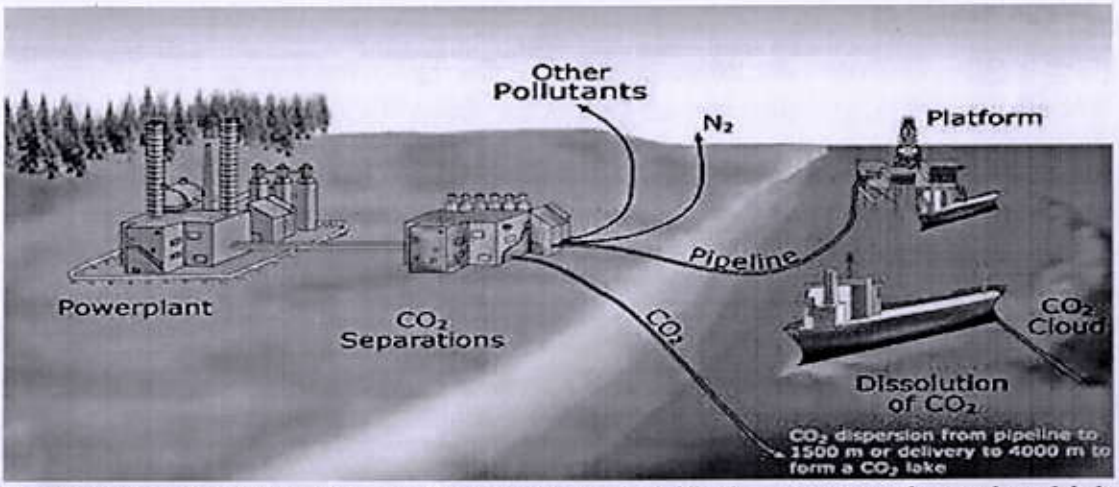
Methods of carbon sequestration:-

1. **Geological sequestration**: (Underground) Geologic Storage involves capturing anthropogenic CO_2 before it enters the atmosphere and injecting it into underground formations. Once CO_2 is injected deep underground (typically more than 800 meters) it is trapped in minute pores or spaces in the rock structure. Impermeable cap rocks above the storage zones act as seals to ensure the safe storage of CO_2.



2. **Ocean Sequestration**: (Deep in ocean) Carbon is naturally stored in the ocean via two pumps, solubility and biological and there is analogous man made methods, direct injection and ocean fertilization, respectively. At the present time, approximately one third of human generated emission is estimated to be entering the ocean.

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3. **Terrestrial Sequestration**: (In plants and soil) the process through which CO2 from the atmosphere is absorbed naturally through photosynthesis and stored as carbon in biomass and soils.



Carbon sources and carbon sinks

Carbon source: A forest is considered to be a carbon source if it releases more carbon than it absorbs. Anthropogenic activities such as the burning of fossil fuels have released carbon from its long-term geologic storage as coal, petroleum and natural gas and have delivered it to the atmosphere as carbon dioxide gas.

Carbon sink: The main natural carbon sinks are plants, the ocean and soil. Plants grab carbon dioxide from the atmosphere to use in photosynthesis; some of this carbon is transferred to soil as plants die and decompose. The oceans are a major

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carbon storage system for carbon dioxide. Marine animals also take up the gas for photosynthesis, while some carbon dioxide simply dissolves in the seawater.

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Enhancing Soil Health: A Comprehensive Review of Soil Organic Matter

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INTRODUCTION

Soils are categorized based on their organic matter content as either mineral or organic. Mineral soils, which constitute most of the world's cultivated land, contain between a trace amount and 30 percent organic matter. Organic soils, on the other hand, are naturally rich in organic matter due to climatic conditions. Despite having more than 30 percent organic matter, organic soils are not typically used for vital cropping. This bulletin focuses on the dynamics of organic matter in cropping soils, discussing factors that deplete organic matter and the resulting negative effects. It then explores proactive solutions, reviewing various practices that can increase organic matter content and the subsequent benefits for land and crops. Soil organic matter comprises any material produced by living organisms (plant or animal) that returns to the soil and undergoes decomposition. It includes a range of materials, from intact plant and animal tissues to highly decomposed humus. Most soil organic matter originates from plant tissues, which are composed of 60-90 percent moisture and dry matter containing carbon, oxygen, hydrogen, and small amounts of sulfur, nitrogen, phosphorus, potassium, calcium, and magnesium. Although these nutrients are present in small amounts, they are crucial for soil fertility management. Soil organic matter consists of various components, including an active organic fraction with microorganisms (10-40 percent) and resistant or stable organic matter (40-60 percent), also known as humus. According to Tate (1987) and Theng (1987), soil organic matter can be practically divided into aboveground and belowground fractions. Aboveground organic matter includes plant and animal residues, while belowground organic matter consists of living soil fauna and microflora, partially decomposed plant and animal residues, and humic substances.

The carbon-to-nitrogen (C:N) ratio indicates the type of material and its ease of decomposition, with high C ratio woody materials being more resistant to decomposition than low C

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A NOVEL APPROACH TRANSFORMING AGRICULTURE

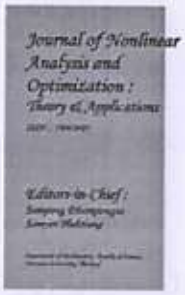
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ABSTRACT

Agriculture is a fundamental and steady sector as it generates and supplies raw materials for the food and feed industries. Due to the rising global population, increased nutrient depletion, the need to boost total food grain production, decreasing arable lands, limited water availability, declining soil organic matter, climate change, and various other factors, it is essential to adopt modern technologies like nanotechnology in agricultural sciences. Nanotechnology offers numerous applications across all stages of production, processing, storage, packaging, and transportation of agricultural products. The goal of using nanomaterials in agriculture is to reduce the amount of spread chemicals, minimize nutrient losses in fertilization, and increase yield through improved pest and nutrient management. Key benefits of nanotechnology in agriculture include specific applications like nanofertilizers and nanopesticides, which help in monitoring product and nutrient levels to enhance productivity without contaminating soil and water while providing protection against various insect pests and microbial diseases. Nanotechnology can also act as sensors for monitoring soil quality in agricultural fields, thus maintaining the health of agricultural plants (Prasad et al., 2017). It promises to revolutionize agriculture and the food industry by introducing new techniques such as precision farming, enhancing plants' nutrient absorption, more efficient and targeted use of inputs, disease detection and control, resilience against environmental stresses, and advanced systems for processing, storage, and packaging. Nanoclays and zeolites can increase the efficiency of applied fertilizers and restore soil fertility by releasing fixed nutrients. Nanoherbicides are being developed to tackle perennial weed management and deplete weed seed banks. Environmental pollution levels can be swiftly assessed using nano smart dust and gas sensors (Shaimaa and Mostafa, 2015).

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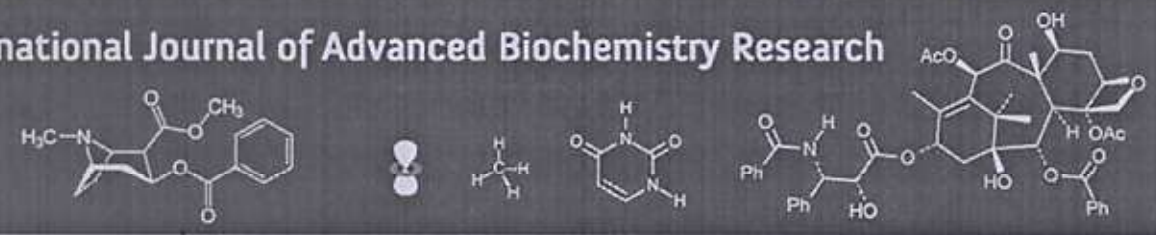
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Effectiveness of plant extracts and oils in managing blue mould rot of orange caused by *Penicillium italicum*

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Abstract
The study aimed to evaluate the efficacy of the plant extracts and oils, in the inhibition of *Penicillium italicum* causal agent of blue mould on orange fruits. The results showed that all the tested extracts at 5, 10 percent and oils at 4 percent had a high inhibitory effect against *Penicillium italicum*. Extracts of garlic cloves is highly effective and showed 95.26 percent inhibitory effect against mycelial growth and 52.75 percent reduced disease severity at 10 percent concentration. Edible and non-edible oils were applied at 4 percent concentration in which eucalyptus oil found most effective in control of mycelial growth (94.65%) and disease severity (50.63%) on orange fruits. Results have shown that treatments have caused abnormal radial growth. In plant extracts and oils maximum inhibition was recorded with the use of garlic cloves and eucalyptus oil.

Keywords: Orange, blue mould, inhibition, plant extracts, oils, mycelial growth

Introduction

Orange (*Citrus reticulata*) is the most common among citrus fruits grown in India. *Citrus reticulata* derived from Latin word reticulata it means "netted". Orange contributed nearly 40% production of the total area under citrus grown area in India. In India most common fruits are the orange (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*) which sharing 41, 23 and 23 percent respectively of all citrus fruits produced in the country. In India Maharashtra, Madhya Pradesh, Assam, Odisha, West Bengal, Rajasthan, Nagaland and Mizoram are growing states of orange. India is leading producer of citrus with an area of 428 million hectare, production 5101 metric ton and productivity was 11.9 metric ton/hectare during 2017-18 (Anonymous, 2017-18) [3].

The germ tube elongation of *Penicillium italicum* stimulated by the citrus volatile myrcene and then followed by limonene, which plays inhibited role on *Penicillium expansum* (Droby *et al.*, 2008) [13]. In fruits post-harvest diseases that account for decay losses of citrus fruits (Palou, 2014) [28].

Among the post-harvest diseases of citrus, green mould (*Penicillium digitataum*) and blue mould rot (*Penicillium italicum*) are commonnly observed in all citrus growing areas throughout the world (Palou *et al.*, 2001; Plaza *et al.*, 2004) [27, 30].

Disease severity from 9 to 14% caused by green mould was recorded in sweet oranges (Reddy *et al.*, 2008) [33].

Higher incidence and severity of green mould has been reported in fruit markets located in tropical conditions (Smilanick and Sorenson, 2001) [38].

The blue and green moulds (Penicillium species) have become increasing most important on post-harvest losses of citrus in Nepal (Gautam *et al.*, 2002) [16].

Extracts of garlic cloves at all concentrations controlled the growth of artificially inoculated *Penicillium digitatum* and *Penicillium italicum* the cause of blue and green mould respectively as compared to water control (Obagou and Korsten, 2003) [26]. Pathogens being necrotrophs, enter into fruit through rind wounds caused during the pre-harvest and post-harvest phase including transportation (Ballester *et al.*, 2010) [8].

Crude extract of medicinal plants gave goodantifungal activity of extracts was observed (Daferera *et al.*, 2000) [11].

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RESEARCH ARTICLE

Estimates of heterosis for yield and its attributing traits in pumpkin (*Cucurbita moschata* Duch. ex Poir.)

Mahendra Kumar Yadav*# and D. P. Singh

Abstract

The investigations were carried out to evaluate the 28 F_1 hybrids of pumpkin, which were grown in a randomized complete block design with three replications during Zaid 2021 at the main experiment station, Department of Vegetable Science, Kalyanpur, CSA University of Agriculture and Technology, Kanpur (U.P.). Observations were recorded on nineteen quantitative traits *viz.*, days to first male flower appearance, days to first female flower appearance, node number to first male flower appearance, node number to first female flower appearance, vine length, internodal length, branches per plant, days to first harvest, average fruit weight, fruits/plant, equatorial circumference of fruit, polar circumference of fruit, flesh thickness, total soluble solids, dry matter content, moisture content, seeds per fruit, specific gravity and fruit yield per plant. The highest fruit yield per plant was recorded in hybrids viz. Azad Pumpkin-1 × P-40-16, Azad Pumpkin-1 × Punjab Samrat, P-40-16 × Punjab Samrat, Azad Pumpkin-1 × P-35-16, Narendra Agrim × Punjab Samrat and Azad Pumpkin-1 × DVRP-2-5 in F_1, exhibited significant and desirable heterosis in respect to standard variety with days to first male flower appearance, days to first female flower appearance, node number to first female flower appearance and days to first fruit harvest.

Keywords: Pumpkin, heterosis, quantitative, qualitative traits and fruit yield.

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Introduction

Pumpkin (*Cucurbita moschata* Duch. ex Poir.) is an economically important vegetable crop. It has a high carotene content, is resilient, and has excellent keeping quality. It is an amphidiploid vegetable that is an herbaceous annual and is sexually reproduced. Its genomic structure, AABB, is identical. It consists of roughly 27 wild and domesticated species with the same 2n = 40 chromosomal number. Of these species, the five that are most frequently farmed are *Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita ficifolia*, *Cucurbita pepo*, and *Cucurbita mixta*. Native areas of the cultivated species of *Cucurbita* appear to be North Mexico of Mexico City for *C. pepo*, South America for C. maxima, South America, Central America and Mexico for *C. moschata*, Mexico and South Mexico City for *C. mixata* and Central America and Mexico for *C. ficifolia* (Hurd et al., 1971). Pumpkin can be improved as a crop by evaluating its genetic diversity and taking advantage of heterosis. Pumpkin is a particularly adaptable crop for heterosis breeding because of its monoecious nature, big flower size, ease of pollination, high proportion of fruit set from pollinated female flowers, large amount of seeds per fruit, and low seed rate required per unit area. There is a lot of room for successfully utilizing hybrid vigor. To find crosses that have a high degree of exploitable heterosis, it is essential to have knowledge on

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OPEN ACCESS

Natural Products Revolutionizing and Innovative Drug Discovery and Development Strategies: Healthcare Challenges and Future Perspectives

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Plants and other organisms serve as sources of secondary metabolites that can be used as leads in the drug development industry. Increasing health issues such as antibiotic resistance and cancer require new drug development methods. Natural products offer a rich source of structurally complex molecules that have been selected to have an impact on multiple biological systems. Biotechnologies such as synthetic biology, computation, and high throughput screening are improving the discovery and characterization of natural product-based drug leads. However, there are difficulties in ensuring a continuous supply of these valuable natural products. The discovery of new drugs using plant-derived chemicals is a huge area but prospects can be enhanced through cross-cutting collaborations among research areas such as ethnobotany, chemistry and pharmacology. Sustainable therapeutics discovery for natural product-based medicines: integrated data-driven and traditional knowledge-based strategies for natural products discovery. In conclusion, natural products remain crucial in ensuring success in the future of providing medicine for increasing pressing healthcare needs.

Keywords: Natural products, Drug discovery, biologically active compounds, Healthcare challenges, Synthetic biology, Interdisciplinary collaborations

1. Introduction

A substance obtained from a living organism with medicinal properties can assist in creating and advancing new pharmaceuticals. Chemical components vary in structure and uniqueness in crude substances sourced from medicinal plants, animals, microbes, or fermentation broths.

The pharmaceutical and biotechnology industries depend significantly on natural products since numerous modern drugs are developed from naturally existing compounds. Various intricate medicinal compounds are mixed to create healing substances that can be administered through injection, ingestion, and inhalation (Mathur and Hoskins, 2017; Chen et al., 2020). A significant hurdle is presented by the high occurrence of infectious and non-infectious diseases and the difficulty in developing safe and efficient treatment choices. Even with the introduction of medications for the management and treatment of conditions

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Clinical Applications of Mass Spectrometry in Toxicological Investigations: Advancing Therapeutic Drug Monitoring and Analysis

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Mass spectrometry (MS) has revolutionized therapeutic drug monitoring (TDM) and analysis in clinical toxicology. This review studies the recent advancements and applications of MS in toxicological investigations, highlighting its role in improving TDM precision and expanding the analyte detection scope. MS's versatility allows for precise drug quantification across various concentrations, enhancing patient care through personalized dosing regimens and monitoring drug efficacy and toxicity. MS-based assays provide superior specificity and sensitivity compared to traditional immunoassays, especially in complex matrices like blood, urine, and tissue samples. MS aids in identifying and quantifying novel psychoactive substances and designer drugs, addressing emerging challenges in clinical toxicology. The rapid adaptation of this substance to changing drug landscapes is a crucial aspect of its essential role in forensic and emergency toxicology. MS, alongside TDM, is increasingly being utilized in postmortem toxicology, aiding in thorough investigations into drug-related deaths, and contributing to forensic pathology and public health initiatives. Despite its widespread adoption, challenges such as standardization of methodologies, complex data interpretation, and cost-effectiveness persist. The integration of MS into clinical practice and its potential in toxicological investigations will be significantly enhanced by addressing these challenges. MS is crucial in postmortem toxicology, aiding in forensic pathology and public health interventions, but challenges like standardization, data interpretation, and cost remain. MS's application in toxicology is continuously evolving, providing exceptional capabilities in TDM, new psychoactive substances (NPS) detection, and forensic investigations. Future technological advancements are expected to enhance the clinical utility of MS, leading to improved patient outcomes and public health. MS continues to revolutionize clinical toxicology, offering exceptional capabilities in TDM, NPS detection, and forensic analyses, with continued advancements promising improved patient care and public health outcomes.

Keywords: Mass Spectrometry, Toxicological investigations, Therapeutic drug monitoring, Drug discovery, Insilico-methodologies

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FREE SPEECH AND THE PREAMBLE OF THE INDIAN CONSTITUTION: AN OVERVIEW

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Introduction

Free speech is the right to express one's opinions and ideas without fear of government retaliation or societal sanction. It encompasses a broad range of activities, including spoken words, written communications, and symbolic actions. Free speech is fundamental to the functioning of a democratic society as it allows for open discussion, debate, and the exchange of ideas. This freedom is essential for the pursuit of truth, fostering creativity, and ensuring that citizens can participate meaningfully in the democratic process.The importance of free speech cannot be overstated. It serves as a cornerstone for other rights and freedoms, enabling individuals to advocate for change, criticize government actions, and hold those in power accountable. Free speech also supports personal autonomy and self-expression, allowing individuals to define their own identities and share their experiences. Moreover, a robust culture of free speech contributes to social progress by challenging outdated norms and sparking innovation.

The Preamble of the Indian Constitution serves as an introduction to the document, outlining the fundamental values and guiding principles upon which the nation is founded. The Preamble succinctly encapsulates the essence of the Indian Constitution. It highlights key ideals such as sovereignty, socialism, secularism, democracy, and republicanism. Additionally, it emphasizes the goals of justice, liberty, equality, and fraternity, which are crucial for the holistic development and well-being of the nation and its citizens.

Connection Between Free Speech and the Preamble

The Preamble's commitment to "Liberty of thought, expression, belief, faith and worship" directly relates to the principle of free speech. This connection underscores the intention of the framers of the Constitution to establish a society where individuals can freely articulate their thoughts and ideas. Liberty of expression is essential for realizing the democratic vision outlined in the Preamble, as it empowers citizens to participate in governance, advocate for their rights, and contribute to societal progress.

Moreover, the principles of justice, equality, and fraternity mentioned in the Preamble are intrinsically linked to the freedom of speech. A just society cannot exist without the ability to question and criticize injustice. Equality of status and opportunity requires that all individuals have an equal voice in public discourse. Fraternity, or the promotion of unity and solidarity among citizens, is strengthened when diverse voices and perspectives are heard and respected.

In essence, the Preamble and the constitutional guarantee of free speech work in tandem to build a vibrant, inclusive, and dynamic democracy. They ensure that India remains a nation where the exchange of ideas is not just tolerated but encouraged, fostering a culture of open dialogue and mutual respect.

Historical Context

Evolution of Free Speech in India

Free speech in India has a rich and complex history, deeply intertwined with the country's struggle for independence and the subsequent formation of its constitutional democracy. The concept of free speech evolved significantly over time, influenced by colonial rule, nationalist movements, and the drafting of the Indian Constitution.

Role of Free Speech During the Indian Independence Movement

The Indian independence movement, spanning the late 19th and early 20th centuries, was marked by a fervent demand for civil liberties, including free speech. During British colonial

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Research Paper - LAW

Exploring the Effectiveness of Lok Adalat as an Alternative Dispute Resolution Mechanism

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SUBJECT- LAW

"Decentralizing Justice: Nyaya Panchayats, Gram Nyayalayas, and Access to Legal Services in Rural India"

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CORPORATE SOCIAL RESPONSIBILITY IN THE ERA OF GLOBALIZATION: A LITERATURE REVIEW

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Introduction

In today's interconnected world, the role of corporations extends far beyond traditional business operations and profit-making. Corporate Social Responsibility (CSR) has emerged as a crucial aspect of business strategy, reflecting a company's commitment to ethical practices, environmental sustainability, and social well-being. At the same time, globalization—the increasing interdependence of economies, cultures, and populations—has transformed the landscape in which businesses operate. This dual dynamic of CSR and globalization presents both significant challenges and substantial opportunities for corporations worldwide.

Corporate Social Responsibility, historically rooted in the philanthropic efforts of businesses, has evolved into a comprehensive framework encompassing environmental stewardship, ethical labor practices, and community engagement. Companies are now expected to balance their economic objectives with broader societal goals, contributing positively to the communities and environments in which they operate. This shift is driven by stakeholders—consumers, investors, employees, and governments—who demand greater transparency and accountability from businesses.

Globalization amplifies the importance of CSR, as companies expand their operations across borders, encountering diverse regulatory environments, cultural expectations, and socio-economic conditions. The global marketplace requires businesses to navigate these complexities while maintaining consistent ethical standards. Moreover, globalization offers unprecedented opportunities for companies to innovate, collaborate, and implement sustainable practices on a global scale.

This literature review aims to explore the intricate relationship between CSR and globalization, examining how these forces interact to shape corporate behavior and impact. By synthesizing existing research, this paper will identify the challenges multinational corporations face in implementing effective CSR strategies across different regions and highlight the opportunities globalization provides for advancing CSR objectives. Furthermore, this review will offer insights into best practices and potential strategies for businesses to enhance their CSR initiatives in a globalized world.

Understanding the interplay between CSR and globalization is essential for businesses seeking to thrive in an increasingly complex and interconnected environment. This paper will provide a comprehensive analysis of the current state of research on this topic, identify gaps in the literature, and propose directions for future studies, ultimately contributing to a deeper understanding of how companies can achieve responsible and sustainable growth in the global marketplace.

Literature Review

Carroll, A. B. (1991) in the paper "The Pyramid of Corporate Social Responsibility: Toward the Moral Management of Organizational Stakeholders" presents a foundational model of CSR, emphasizing the importance of economic, legal, ethical, and philanthropic responsibilities. This

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CIRCULAR ECONOMY – A WAY TO SUSTAINABLE DEVELOPMENT

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Abstract
Countries around the world are grappling with an unprecedented number of challenges, including global supply shortages, geopolitical tensions, and inflation. At the same time, the climate crisis and unsustainable resource consumption demand immediate attention. At current cunsumption rates, humanity is using the equivalent of 1.75 times the earth's natural resources each year. The solution, a circular economy, will basically reshape the world- and it is already underway. There are many drivers of Circular Economy including changing consumer needs, limited resources and technological advancements. Circular flow can be ensured with sustainable design, sharing of resources, remanufacturing, repairing and recycling. But there are many challenges and obstacles in the way of implementing Circularity. Governments, Industries, Researchers Consumers and citizens should come forward with legitimate suggestions and solutions to make the Circular Economy successful for the sustainable development.

1. Introduction

A circular economy means rejecting the linear take-make-waste economy and adopting a regenerative model using processes that restore, renew or revitalise their own sources of energy and materials and wasting as little as possible. It is a model comprising production and consumption, which includes sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. Practically, it means reducing waste to the minimum. It represents a decoupling of economic growth from resource consumption. For companies, it means conserving materials, extending a product's lifetime through repair and reuse, and ultimately recycling. It also includes improving utilization through new business models, such as those that offer products as a service and sharing ecomomy platforms.

The circular economy is an exciting and inspiring approach to create a new economy, a new way of consuming, using and producing products. It aims to create a system without waste that keeps all resources flowing continuously between producers and users. A system with low environmental impact and high economic activity.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It is essential to treat sustainability as the sum of three closely interconnected areas, namely the economy, society and the natural environment. To achieve sustainability, these three areas must be in sync, without harming each others' interest. Therefore, the main aim of sustainable development is for economic, social and environmental development to support and not to contradict each other.

2. Linear Versus Circular Economy

All products have a lifecycle. During the first industrial revoluton, this lifecycle became increasingly linear. In other words, the economy produced raw materials, transformed them and then discarded them. The circular approach, by contrast, extends the lfecycle with methods that include the re-use, re-manufacturing or recycling of products. With the help of modern technology, circular economy is capable of creating added value and making economic processes more efficient. It uses solutions that allow companies to create added value with materials that had previously incurred costs for them as waste, and thus increases profitability as well.

3. The Drivers of Circular Economy

3.1 Changing Consumer Needs-

Sustainability is being very important for generation Y (20-35 years old) and Z (15-20 years old). The younger generations are making efforts towards creating value for the whole society. They are no

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IOT'S ROLE IN SHAPING THE FUTURE OF ACADEMIC EDUCATION

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ABSTRACT

The threshold for education has been elevated to unprecedented heights by digital technology. Although traditional classroom-based education is still extensively employed in many parts of the world, a variety of online tools have significantly improved the effectiveness of education as a supporting medium. The concept of connected devices or items has led to a recent increase in the popularity of the Internet. This has led to the creation of an efficient information-sharing network system. Information exchange over the internet has led to the development of a smart system that allows children to flourish in a competitive atmosphere. IOT devices and their potential uses in higher education have been carefully investigated through a thorough review of the literature and secondary data collection. . The goal of this project is to investigate how higher education will use the Internet of Things in the future. The study has demonstrated the variety and applications of IoT devices utilized in postsecondary educational settings. There has been studies on how IoT might improve students' chances of obtaining higher education. Because of the research, the next generation will have greater opportunities to pursue vocations. The results may significantly affect how kids are taught to think critically and creatively.

Keywords: *Internet of Things (IoT), connected devices, smart system*

INTRODUCTION

The Internet of Things (IoT) is a revolutionary technical breakthrough that paves the way for ubiquitous human-machine and machine-to-environment connection. Incorporated sensors and actuators will collect data, which will be sent to specialized programs to be transformed into useful insights. Due to its potential to alter current industrial and corporate processes, IoT has been recognized as a cornerstone of Industry 4.0.

As the Internet of Things (IoT) develops and becomes more pervasive, the world around us is becoming both more intelligent and more linked than ever before. Sustainability, efficiency, accuracy, and economy have all been increased across the board as a result of this. Many sectors have benefited from implementing IoT, including healthcare, transportation, energy, education, environmental monitoring, smart buildings, and smart cities. IoT is being used by government agencies and educational institutions to improve efficiency, make better use of data, and advance sustainable practices. The usage of smart items and wearable gadgets is widely established at a number of colleges [2]. Education has rapidly adopted and made considerable use of enabling technologies such as sensors, processors, and other wearable devices since they are widely available, cheap, and simple to mass create. The impact of IoT on classroom instruction is the subject of this study.

Internet of Things in Education

A passive knowledge-transfer paradigm has given way to an active, collaborative, self-directed approach as a result of technology's disruptive influence on today's educational institutions. Many educational institutions have thus been forced to review their approaches. Technology has, wherever it has been deployed, enhanced student engagement, raised instructor effectiveness, and improved student performance, to just a few instances.

A few of the tools, technologies, and strategies that are now propelling innovation in education are consumer technologies, digital strategies, internet technologies, enabling technologies, learning technologies, social media technologies, and visualisation technologies. A subset of Internet technology known as the Internet of Things (IoT) offers the classroom a number of advantages. IoT technologies make it easier for educational institutions to collect vast amounts of data from sensors and wearables and to act on this data in useful ways. These sorts of solutions can help kids learn more about their environment through the use of QR codes and other technology. To utilize the resources of

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AN IN-DEPTH ANALYSIS OF IMPLEMENTING BLOCKCHAIN TECHNOLOGY FOR SECURE IOT NETWORKS IN FUTURE INDIAN SMART CITIES WITH 5G: APPROACHES, CHALLENGES, AND OPPORTUNITIES

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Abstract:
Blockchain technology is emerging as a crucial technology for securing the Internet of Things (IoT) systems in smart cities beyond 5G in India. This paper provides a comprehensive survey on the use of blockchain technology in establishing secure IoT-enabled smart cities in India through approaches, processes, challenges, and opportunities. The paper focuses on real-world applications and fundamental development of blockchains, including a comparison with databases. In addition, this paper offers a deep insight into the integration challenges, benefits, and opportunities of using blockchain in secure smart cities through case studies, which can provide essential support for similar practices.

1. Introduction

The advancements in intelligent technology have led to the development of smart cities and applications. Smart cities are places where traditional networks and services are made more efficient using digital and telecommunication technologies, benefiting inhabitants and businesses. Data and Communication Technology plays a crucial role in enhancing the quality, performance, and interactivity of urban services, reducing costs and resources consumption, and increasing contact between citizens and governments. Smart technologies in homes, such as smart appliances and lighting, are increasingly popular.Security issues in smart cities are being discussed, and this paper explores the use of blockchain and 5G technologies for secure IoT-enabled smart cities beyond 5G in India. The paper provides a comprehensive survey on the use of blockchain technology in establishing secure IoT-enabled smart cities beyond 5G in India, demonstrating its true potential in ensuring security and enhancing IoT systems' capabilities. It also identifies potential challenges and future directions of using blockchain, and offers a deep insight into the integration challenges, benefits, and opportunities of using blockchain in secure IoT-enabled smart cities through case studies.

2. Blockchain Technology

Blockchain technology is a decentralized and distributed ledger system that securely and efficiently stores and transfers sensitive information. It is based on blocks, which are linked together in a chronological manner to create a chain of blocks. When a new block is added to the chain, most nodes in the network must verify its validity and reach a consensus on its placement in the chain. Once a block is added, it is difficult to alter its contents as each block contains a reference to the previous block's contents.

Key features of blockchain technology include its distributed, cryptographically secure, immutable, time-stamped, consensus-based, and smart contract enabled features. The ledger is distributed and synchronized across all network participants, with each user or node having an exact copy. It is protected by complex mathematical algorithms and cryptographic keys, making it highly secure. Blocks also store the time and date of each transaction, and the distributed consensus algorithm ensures consensus on the validity of new blocks, ensuring their chronological placement in the chain. This makes it difficult for anyone to gain control of the blockchain and alter or defraud the system. Lastly, smart contracts are self-executing contracts that automatically enforce obligations and promises made

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GIS: BRIDGING THE GAP BETWEEN DATA AND LOCATION

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Abstract:
Geographic Information Systems (GIS) is a computer-based technology used to collect, store, analyze, and present information related to specific geographical locations. It enhances decision-making and is widely used in various industries. GIS consists of hardware, software, users, and entered data. It is important due to modern technology, increased data methods, educational awareness, and potential for future ventures. GIS applications range from analyzing retail sites to managing disaster recovery projects. The components of GIS include hardware, software, users, and data. Spatial data is a vital component of GIS, categorized into vector and raster data. Remote sensing and GPS are used for data collection and management in GIS.
Keywords: Geographic Information Systems, computer-based technology, data analysis, spatial data, data collection and management

1. Introduction

GIS, short for Geographic Information Systems, is a computer-based technology that collects, stores, analyzes, and presents information that is related to specific geographical locations. This technology is widely used due to its ability to enhance decision-making and yield better outcomes, particularly when it comes to geographical matters. GIS consists of hardware, software, users, and the data that is entered into the system. Various industries, such as insurance, telecommunications, and vehicle tracking, employ GIS to enhance their operations. It enables companies to provide improved customer service, as well as identify and evaluate their assets and their performance. Furthermore, GIS enables us to visualize and understand the world from multiple perspectives.

1.1 Definition of Geographical Information Systems

Geographical Information Systems are computer-based systems for the input, storage, retrieval, manipulation, analysis and output of spatial data. In this context, spatial data is understood as information which has a spatial or geographical reference, which includes data about the earth's physical features, the built environment, and the natural and human environment.

1.2 Importance of Geographical Information Systems

The evolution of what is now considered as a GIS started as far back as the 1970's. It has steadily grown as an important element in academia and industry. In recent years, the subject has also gained importance at the government level. There are several reasons why GIS has become an important tool for gathering and handling spatial data and various organizations are using GIS for a variety of reasons. The growing importance of GIS can be attributed to several factors such as: modern technology, increased methods of data input and information, greater educational awareness of GIS and finally the realisation of the potential that GIS holds for future commercial ventures.

1.3 Applications of Geographical Information Systems

There are innumerable applications of GIS globally and in every kind of industry. Some of the main potential uses of GIS for businesses, governments, and individuals include using GIS to analyze potential retail sites, identify and quantify risk, map unstructured data, deliver slide presentations, transfer information to digital eBooks, give sales representatives more data, and even plot where a company's billboards are located. GIS has also been employed for important life-saving applications in various countries. For instance, in the aftermath of the South Asian tsunami of 2004, GIS technology was utilized in many disaster recovery projects. In the US, it was used to track Hurricane

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Response of cluster bean (*Cyamopsis tetragonoloba* L. Taub.) to organics and fertilizers in hyper arid region: A review

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Bhawariya A, Gayathri. Response of cluster bean (*Cyamopsis tetragonoloba* L. Taub.) to organics and fertilizers in hyper arid region: A review. AGBIR.2024;40(2):980-983.

Cluster bean (*Cyamopsis tetragonoloba* L.Taub.), also known as guar, is a coarse, drought-tolerant legume that is primarily grown during the kharif season in arid and semi-arid regions of the country. Important minerals such as calcium, phosphorus and iron are generally lacking in cereals but abundant in this legume. The natural polysaccharide water-soluble polymer found in endosperm, known as galactomannan gum, is the primary product used in many industries. Cluster bean cultivars with a high gum content (>32%) are more suitable for export. Panchagavya and Jeevamrut are affordable, eco-friendly organic concoctions crafted from cow by-products such as dung, urine, milk, curd and ghee. Panchagavya is an effective plant growth stimulant and organic product that can help promote growth and provide immunity in the plant system. Panchagavya contains growth regulatory substances such as Indole-3-Acetic Acid (IAA) and Gibberellic Acid (GA), which are required for crop growth. Jeevamrut stimulates significant biological activity in the soil, making nutrients available to crops. Cow urine has anti-fungal properties and is a good source of plant nutrients. Cow manure is high in minerals, specifically nitrogen, phosphorus and potassium. When mixed with soil, it promotes the growth of beneficial microorganisms.

Key Words: *Panchagavya; Cluster bean; Jeevamrut; Cow urine; Cow dung extract; Urea*

INTRODUCTION

Cluster bean improves soil fertility by fixing a significant amount of atmospheric nitrogen. It can fix approximately 37-196 kg of atmospheric nitrogen per hectare per year in soil. It is sometimes used to reclaim saline and alkaline soils [1-5]. Fertilizers and organic manures play an important role in increasing cluster bean yield [6]. Nitrogen stands as the paramount nutrient crucial for the growth and development of plants. Nitrogen, as a key component of plant nutrition, is essential for the synthesis of chlorophyll and amino acids [7]. Insufficient nitrogen can significantly reduce yield and degrade produce quality, particularly protein content.

Because arid soils are both hungry and thirsty, foliar nutrient application is critical for increasing crop production and productivity. As a result, it may be necessary to conduct research to identify appropriate nutrient sources for foliar application in order to increase crop quantity and quality. Due to environmental concerns, there is an urgent need to reduce the use of chemical fertilizers in agriculture and chemical-free alternatives are being sought to improve crop productivity and quality. One option is to use organic nutrients or growth regulators, which can promote plant growth *via* a variety of mechanisms such as organic nutrient supply or plant hormone production. Panchagavya and Jeevamrut are cost-effective, environmentally friendly organic formulations crafted from cow-derived substances like dung, urine, milk, curd and ghee. Panchagavya is an effective plant growth stimulant and organic product that can help promote growth and provide immunity in the plant system. Farmers in South India are using Panchagavya for sustainable agriculture [8]. It is used to activate the soil, protect plants from disease and improve the nutritional value of fruits and vegetables. Panchagavya contains growth regulatory substances such as IAA and GA, which are required for crop growth [4]. It is used for foliar spraying, soil application with irrigation water and seed treatment. Panchagavya is an organic product endorsed for enhancing crops in organic farming [9]. Jeevamrut is a liquid organic manure that contains a high concentration of organic carbon, nitrogen, phosphorous, potassium and other micronutrients (Ca, S and Fe) that crops require. Jeevamrut has demonstrated greater effectiveness compared to other manures and can be utilized in combination with them.

Jeevamrut stimulates significant biological activity in the soil, making nutrients available to crops. Cow urine has anti-fungal properties and is a good source of plant nutrients. It's been used in crop production for ages. Cow urine contains approximately 1.0% nitrogen, traces of phosphorus and 1.0% potassium. Annually, approximately 2400 to 2500 liters of urine are produced per animal. If this urine was not conserved, the nitrogen, which is primarily in the form of urea, would be rapidly lost as ammonia. It is also used as a natural disinfectant and pest repellent and it is the primary ingredient in Panchagavya (an organic crop booster prepared and sprayed by Indian farmers) [10]. Cow manure is high in minerals, specifically nitrogen, phosphorus and potassium. When mixed with soil, it promotes the growth of beneficial microorganisms. Manure can also improve the texture of the soil and help it retain moisture.

LITERATURE REVIEW

Effect of organics and fertilizers on cluster bean

SGrowth parameters: When wheat (*Triticum aestivum* L.) was sprayed with urea 4% during tillering, stem elongation and boot stage, the plant height and spike length increased significantly [11]. A pot experiment revealed that applying 3% Panchagavya spray 10 days after sowing resulted in significantly increased lateral roots, number of nodules, fresh and dry mass of the plants and total leaf area [12]. While working at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, the application of RD F+beejamruth+jivamrut+Panchagavya resulted in significantly higher plant growth and root length of tomato (*Lycopersicon esculentum*) compared to other treatments [13]. A pot experiment on black gram (*Vigna mungo*) found that applying 3% Panchagavya at the 15th, 25th, 35th and 45th days of the interval period resulted in a significant improvement in plant height (42.6 cm) and number of branches plant^{-1} (10) when compared to Nitrogen, Phosphorus and Potassium (NPK) and control. The foliar application of Panchagavya also significantly improved the chlorophyll content (Chlorophyll a, b and total 2.2, 0.9, 6 and 3.2 mg g^{-1}, respectively) and N content of root nodules (5.50 g) when compared to NPK and control [14]. Applying Panchagavya (3%) 15 days after flowering resulted in increased chickpea plant height (37.01 cm), number of branches per plant (5.22) and root nodules (20.50) [15]. At 75 Days After Sowing (DAS), spraying chickpea with 2% urea and Diammonium Phosphate (DAP) resulted in the highest Soil-Plant Analysis Development (SPAD) chlorophyll meter readings of 69.6 and 67.5, respectively [16]. A field experiment on summer cowpea at was carried out Agronomy Instructional

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Analyzing the Factors Influencing the Adoption of Technological and Management Innovations by Farmers

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Abstract: The use of innovative machinery depends on several types of factors as financial factors, technological factors, awareness factors and usability. The analysis of the most important effects that decrease the potentiality of the farmers is important. Fruitful use of resources increases the capability of the farmers to use innovative products. The financial capabilities of farmers from developed countries are better than those of developing countries and this brings change to the use of farming technology. The farmers need to understand the usefulness of the agricultural products and machinery. Thus, this determines an important factor which affects the use of innovative technology in farming.

Keywords: Innovative technology, financial sources, different patterns of agriculture, and awareness

1. Introduction

Farming and agricultural activities are demarcated as a primary activity. This helps to generate different raw materials for different industrial sectors. Agriculture contributes 26.4% to employment and 4.3% of global GDP and the productivity of the agricultural sector is increasing with increasing technological advancement. This study has analysed the factors that are affecting the adaptation of modernised management systems and technology in farming activities. The effective factors have been analyzed as well as the suitable methods that could help farmers to implicate modernised technology in farming activities. The most important factors that inversely affect in use of modernised technology are related to the availability of employees and capital investment of the farmers.

2. Methods

Analysing data

The analysis of the agriculture-related data helps to find the factors which effect on using the modernised agricultural methods. Agricultural data helps to determine the causes which affect the sales and use of the machinery used in agriculture. Most dominant agricultural products are produced by a few organisations all over the world.

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AI EMPOWERMENT IN DEMOCRATIC GOVERNANCE: ENHANCING PARTICIPATION AND EFFICIENCY

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Abstract
This abstract delves into the impact of artificial intelligence (AI) on democratic governance, emphasizing its role in enhancing participation and efficiency. By integrating AI technologies, governments can streamline administrative tasks, optimize resource allocation, and improve service delivery. AI empowers citizens by facilitating access to information, enhancing transparency, and fostering civic engagement. However, ethical considerations, accountability, and biases pose challenges. Collaboration between governments, technologists, and civil society is crucial to harness AI's potential effectively. Responsible AI integration can create more inclusive, responsive, and effective governance systems.

Keywords: Artificial Intelligence, Democratic Governance, Participation, Efficiency, Citizen Empowerment, Efficiency, Civic Engagement, Ethical Considerations, Accountability.

Introduction

AI can significantly improve governance, particularly in welfare states aiming to provide social and economic justice to their citizens. As a tool, AI can help formulate and simulate future scenarios, identify hidden patterns in data, and induct automation in knowledge bases and organizational rule-sets. In welfare states like India, where a large portion of the population is not internet-connected, AI can be instrumental in policy formulation and program implementation. Governments can assess the needs of underprivileged and marginalized groups, target the population in need, and assess welfare schemes. AI can also identify potential positive and negative effects of policy decisions and track program implementation to assess their impact on the target population.

The concept of a welfare state has gained attention in India, as it aims to ensure social and economic justice for its citizens. Given the diverse and complex social structure and the challenges in achieving this state, AI can provide futuristic and predictive analysis, aiming to solve problems for marginalized sections and ensure inclusive development.

Background

The welfare state in India aims to ensure the basic standard of living, reduce inequality, and make life worth living. E-governance has been instrumental in achieving these objectives, and the application of artificial intelligence can enhance this approach. AI can monitor policy implementation and welfare schemes more accurately, identifying target groups and the needy to ensure benefits reach the right people. It can also define eligibility and exclusion criteria for schemes, ensuring beneficiaries receive the right benefits. Online and real-time services can provide services at the public's doorstep, while AI can identify critical areas and vulnerabilities, allocate resources properly, and provide feedback systems to satisfy society's needs. AI can also be used as a decision support system to improve policies by simulating models and identifying the best alternatives with available resources.

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RESEARCH ARTICLE

Seasonal abundance of the key cluster bean sucking insect pests and their relationship to abiotic variables

Vijay Kumar*

Kumar V. Seasonal abundance of the key cluster bean sucking insect pests and their relationship to abiotic variables. AGBIR.2024;40(2):993-995.

Cluster bean, scientifically identified as *Cyamopsis tetragonoloba* (L.) Taub and colloquially known as guar, plays a vital role as a leguminous crop resilient to drought conditions, typically grown in arid and semi-arid regions.

A study was carried out at Instructional Farm, RNB Global University, Bikaner during the kharif season of 2023 to investigate the seasonal occurrence of major sucking insect pests affecting cluster bean plants and their relationship with abiotic factors. The research suggested that the jassid abundance fluctuated between 0.50 and 10.40 per three leaves, with peak activity recorded at 10.40 during the 38th standard meteorological week, corresponding to the third week of September. The whitefly population (1.77 whitefly) began during the third week of August commenced on 3rd WAS coinciding with 3rd week of August (34th standard week). After that the pest activity gradually increased up to 8 WAS coinciding with 3rd week of September (38th standard week) and reached a peak level (11.57 whitefly). It was observed that there was a positive correlation between the highest and lowest temperatures. The abundance of jassid resulted significant positive correlation (r=0.67) at 5 per cent level and rainfall had negatively correlation (r=-0.31). The population of whitefly was saw that the maximum temperature showed significant positive correlation (r=0.65) at 5 per cent level, the minimum temperature showed significant positive correlation (r=+0.46) at 1 per cent level and relative humidity revealed significantly negative correlation (r=-0.54) at 1 per cent level. The rainfall showed significantly negative correlation (r=-0.30) at 5 per cent level.

Key Words: *Cluster bean; Pest incidence; Sucking pest; Abiotic factors; Correlation*

INTRODUCTION

Cluster bean, scientifically known as *Cyamopsis tetragonoloba* (L.) Taub and commonly referred to as guar, holds significant importance as a drought-resistant leguminous crop cultivated in arid and semi-arid regions. Its primary role lies in enhancing soil health through atmospheric nitrogen fixation, with an estimated average nitrogen fixation potential of nearly 30 kg N per hectare. Additionally, the plant tends to shed most of its leaves upon maturity, contributing to increased organic carbon content in the soil. This phenomenon is particularly noteworthy in arid regions where elevating organic carbon levels is a major concern.

In India, the states of Rajasthan, Haryana, Gujarat and Punjab stand out as significant producers of cluster beans. Rajasthan and Haryana emerge as the most significant contributors, responsible for around 85% of the whole production. The total cultivated area for cluster beans in India spans approximately 41.03 lakh hectares, yielding an annual production of 18.49 tonnes [1]. Specifically, in Rajasthan, the cultivated area for cluster beans extends over 7.09 lakh hectares, yielding a production of 2.72 lakh tonnes, with a productivity rate of 384 kg per hectare [2]. Notable cluster bean cultivation districts in Rajasthan include Barmer, Churu, Jaipur, Jhunjhunu, Hanumangarh and Alwar. Bikaner alone contributes to this cultivation, covering an area of 7.09 lakh hectares and yielding an annual production of 2.72 lakh tonnes, with a productivity rate of 384 kg per hectare [3].

Insect pests pose significant challenges to the productivity of cluster beans. Notable among them are the leaf hopper *Empoasca motti* Pruthi, whiteflies *Bemisia tabaci* (Genn.), *Acaudaleyrodes rechipora*, aphids *Aphis craccivora* Koch, pod borers *Helicoverpa armigera* (Hub.), leaf perforators *Dichomeris inthes* Meyr, *Maruca testulalis* Geyer and *Protaetia terrosa* G and P. These pests have been identified in previous studies as major threats to cluster bean crops [4-6].

The leaf hopper, *E. motti*, frequently referred to as jassid, is a significant polyphagous pest that detrimentally impacts vegetative growth, resulting in observed seed yield losses of up to 20%. Similarly, the whitefly, *B. tabaci*, a polyphagous insect, poses a substantial threat to crops by extracting large amounts of cell sap. Additionally, the aphid, *A. craccivora*, feeds on plant cell sap, leading to considerable losses. Understanding the timing of pest appearance and fluctuations in their populations is essential for creating successful management plans against these pests [7,8].

MATERIALS AND METHODS

To investigate the seasonal occurrence of primary sucking insect pests affecting cluster bean plants and their relationship with abiotic factors, cluster bean variety RGC-1033 was sown on July 29th 2023. The planting was conducted in a plot measuring 10.0 × 9.0 m², with row-to-row and plant-to-plant distances set at 30 and 10 cm, respectively.

Following their initial appearance, observations on the absolute abundance of jassid and whitefly were promptly recorded. This involved assessing the abundance of jassid and whitefly on five randomly selected and tagged plants within each plot. For each plant, three leaves from different canopy levels (top, middle and lower) were considered for population recording. These observations were conducted during the early morning hours.

The data on weather parameters was obtained from meteorological observatory RNB global university, Bikaner.

Statistical analysis

To analyze the findings regarding the seasonal occurrence of primary sucking insect pests on cluster beans, a simple correlation analysis was conducted between pest population and various abiotic factors. These factors included minimum and maximum temperature, relative humidity and rainfall.

The following equation was applied for calculating correlation coefficient.

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{N\Sigma X^2 - (\Sigma X)^2 N\Sigma Y^2 - (\Sigma Y)^2}}$$

where,

r=Simple correlation coefficient

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Progression of bacterial blight disease (*Xanthomonas axonopodis pv. cyamopsidis*) of clusterbean relation to weather parameters

Vikash Kumar*

Kumar V. Progression of bacterial blight disease (*Xanthomonas axonopodis pv. cyamopsidis*) of clusterbean relation to weather parameters. AGBIR.2024;40(2):989-991.

Clusterbean is the bushy annual herb has a deep-rooted system, is resilient and drought resistant pulse crop grown on sandy soil of arid and semi-arid region. The decline in clusterbean crop productivity is often attributed to several bacterial, fungal and viral diseases, including Bacterial blight (*Xanthomonas axonopodis pv. cyamopsidis*), vascular wilt (*Fusarium moniliformae* and *Fusarium sp.*), Charcoal rot (*Macrophomina phaseolina*), Powdery mildew (*Leveillula taurica*), Anthracnose (*Colletotrichum capsici*), and Alternaria blight (*Alternaria cyamopsidis*). Similarly, the limited and inconsistent national yield of grain and fodder can largely be ascribed to diseases caused by various plant pathogens. Among them, bacterial blight disease caused by *Xanthomonas axonopodis pv cyamopsidis* is a major disease in Rajasthan and India. The correlation between individual weather variable and disease intensity indicated that progression of bacterial blight disease intensity was strongly significantly negative correlated with maximum temperature (X_1) and minimum temperature (X_2). Relative humidity morning (X_3) and relative humidity evening (X_4) was strongly significantly positive correlated with disease intensity. Rainfall (X_5), rainy days (X_6) and sunshine (X_7) were none significantly positive correlated with disease intensity. The coefficient of multiple determinations (R^2) was 94.95 per cent in Kharif 2023. Which means that 94.95 per cent disease intensity was depend on the weather parameters.

Key Words: *Clusterbean; Correlation; Disease intensity; Weather variable*

INTRODUCTION

Clusterbean (*Cyamopsis tetragonaloba*) commonly known as "guar" is an arid and semi-arid legume crop belonging to the family Leguminaceae. Its resilience to drought, attributed to its extensive taproot system and ability to withstand water stress effectively. The name "guar" originates from the Sanskrit word "GAUAAHAR," which translates to "food of cow" or "fodder for livestock". Additionally, referred to by various other names such as khutti, dararretic and guari, this crop is particularly suited for cultivation in rainfed conditions during the Kharif season in India. Notably, it contributes to soil fertility enhancement through atmospheric nitrogen fixation. While predominantly grown during the rainy season, it can also thrive in irrigated settings during the summer period. The seeds are highly valued for industrial gum. It is cultivated mainly in the rainy season as a rainfed crop in arid zones of India and various other parts of the world [1]. The clusterbean seed consists of three parts seed coats (14-17%), the endosperm (35-42%) and the kernel (43-47%). Guar gum (19-43% of the whole seed) is derivative from the endosperm, which is the major beneficial product of the plant. Clusterbean is grown for different purposes, namely vegetables, green fodder, green manure and seed production. Beside all this, used as a concentrate for animals and for the extraction of gum mainly present in the endosperm of the seed, provide a useful raw material for a wide range of industrial products. It is additionally grown for the seeds and drawing out of guar gum manufacturing in India. The clusterbean gum is likewise regarded to contain medicinal significance inside the remedy for diabetes and excessive cholesterol [2]. Clusterbean is commercially grown in India, Pakistan and USA and to a limited extent in Australia, Brazil and South Africa. It has grown in the share of 1:10 as a mixed crop. Overall, India produces approximately 80% of worldwide clusterbean production. It is cultivated on more than 4 m ha in India, Rajasthan only accounts for approximately 80% of the region and production. Left behind to its need in the international market, it has been introduced in the non-conventional growing areas including Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Chhattisgarh [3]. In India, the total area under the clusterbean crop is 39.36 lakh hectare, production 16.24 lakh tones and with yield 428 kg/ha. In Rajasthan, total area under the clusterbean crop is 28.41 lakh hectare, production 12.84 lakh tones and with yield 452 kg/ha. Rajasthan is the leading state in clusterbean production and share more than 70% production in India.

The decline in clusterbean crop productivity is often attributed to several bacterial, fungal and viral diseases, including bacterial blight (*Xanthomonas axonopodis pv. cyamopsidis*), vascular wilt (*Fusarium moniliformae* and *Fusarium sp.*), charcoal rot (*Macrophomina phaseolina*), powdery mildew (*Leveillula taurica*), anthracnose (*Colletotrichum capsici*) and alternaria blight (*Alternaria cyamopsidis*). Similarly, the limited and inconsistent national yield of grain and fodder can largely be ascribed to diseases caused by various plant pathogens. Among them, bacterial blight disease caused by *Xanthomonas axonopodis pv. cyamopsidis* is a major disease in Rajasthan and India. Bacterial blight has become a serious problem in many cluster bean production areas, during monsoon season i.e., July-October [4,5].

MATERIALS AND METHODS

Effect of environmental factors on disease development

The field experiments were conducted under artificial field conditions during kharif season. Observations on the severity of bacterial blight disease of clusterbean were recorded 7 days after inoculation from each plots at weekly interval (July-November). To find out the effect of environmental factors on the progression of bacterial blight disease of clusterbean. Weather variables viz., temperature, relative humidity, rainfall, rainy day and sunshine etc., were recorded and correlation among environmental factors and bacterial blight disease progression was worked out. Means of maximum temperature, minimum temperature, relative humidity (morning), relative humidity (evening), rainfall, number of rainy days, sunshine hours, were symbolized as X_1, X_2, X_3, X_4, X_5, X_6 and X_7, respectively. The per cent disease intensity was calculated and symbolized as Y.

Establishment of linear relationship between per cent disease index and key abiotic factors

The per cent disease index was correlated to the prevailing mean a biotic environmental factor (maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, rainfall, number of rainy days and sunshine). The correlation coefficient values (r) between the per cent disease index and the abiotic factors were computed using the standard methodology as given by Karl Pearson. To study the relationship between seven independent variables (maximum temperature, minimum

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Genetic studies in tomato (*Solanum lycopersicum* [Mill.] Wettsd.) for yield and its attributing traits

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Abstract

The present investigation was carried out to estimate the genetic variability, heritability in broad sense, correlation and path coefficient and genetic divergence (D^2) analysis among 50 genotypes of tomato (*Solanum lycopersicum* [Mill.] Wettsd.) for twelve yield contributing traits during 2021 in Randomized Block Design with three replications. High magnitude of phenotypic as well as genotypic coefficient of variation were observed in case of number fruit per plant followed by unmarketable fruits yield per plant, average fruit weight, marketable fruit yield per plant and total fruit yield per plant. High heritability was recorded for all the traits. High heritability along with high genetic advance was estimated for average fruit weight followed by number of fruits per plant, marketable fruit yield per plant, unmarketable yield per plant and total fruit yield per plant. The polar diameter of fruit was highly significant and positive association with equitorial diameter of fruit. Positive direct effect was exerted by number of fruit per plant followed average fruit weight, polar diameter of fruit on fruit yield per plant. Maximum intra cluster distance was recorded within cluster III and inter cluster distance was recorded between cluster I to V III. Cluster III had maximum number of genotypes and highest per cent contribution towards clustering of genotypes were observe in average fruit weight.

Key words : Correlation, Genetic variability, Genetic divergence (D^2), Heritability, Path coefficient and Tomato.

Tomato (*Solanum lycopersicum* [Mill.] Wettsd.) is a major vegetable crop under the family solanaceae and genus *Solanum* which is herbaceous annual to

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RESEARCH PAPER OPEN ACCESS

Breeding strategies for vegetable improvement: An extensive analysis

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Key words: Biotechnology approaches, Conventional, Molecular breeding, Vegetable production

Abstract

In the face of a burgeoning global population, the imperative of ensuring food security looms large. This review critically examines the pivotal role of breeding strategies in enhancing crop yield, quality, and resilience, with a specific focus on vegetable improvement. Bridging the gap between traditional and modern methodologies, the study explores the historical successes of mass selection and crossbreeding, laying the groundwork for the transformative era ushered in by molecular breeding and genetic engineering. Biotechnology methods have additionally demonstrated to be insufficient to completely replace conventional breeding methods. Trait-specific breeding strategies are examined, emphasizing resilience to illness and abiotic stress, nutritional content, and post-harvest traits. This review analyzes the shortcomings of current breeding strategies, offering a realistic evaluation of the remaining challenges that must addressed overcome. It also discusses the possibility for breeding vegetables in the future, taking into account the need to address the consequences of climate change, incorporate new technology, and develop crops that can endure shifting environmental challenges. This review attempts to give a comprehensive picture of the state of vegetable improvement today and to direct future research efforts in the pursuit of sustainable vegetables production.

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Harnessing silicon to bolster plant resilience against biotic and abiotic stresses

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Soni RK, Modi G. Harnessing silicon to bolster plant resilience against biotic and abiotic stresses. AGBIR.2024;40(2):988-990.

Silicon (Si), though not traditionally considered essential for plant growth, exhibits profound benefits in enhancing crop yields and resilience to abiotic stresses. Its application, particularly in combination with other fertilizers, has demonstrated significant improvements in various crops, including sugar beet, potato, rice, sugarcane and canola. Silicon strengthens cell walls, bolstering resistance to pests and diseases while mitigating the impacts of environmental stressors such as drought, salinity and mineral deficiencies. This multifaceted role extends to radiation-induced injuries, where silicon supplementation has shown promise in mitigating damage and facilitating faster growth recovery in plants. Additionally, silicon deposition in plant tissues, particularly in leaves and hulls, contributes to reduced transpiration rates and enhanced membrane integrity, crucial for combating drought and climatic extremes. Furthermore, silicon alleviates chemical stressors like phosphorus deficiency and toxicity, as well as heavy metal toxicity, through various mechanisms including modulation of metal uptake and distribution. Its role in enhancing salt stress tolerance by decreasing transpiration and improving antioxidant activities underscores its potential in salt-stressed plants. Notably, silicon's beneficial effects vary across plant species, with genetic modifications aimed at enhancing root Si uptake abilities offering promise for widespread application. Overall, silicon emerges as a valuable growth regulator, enhancing plant growth and resilience to stressors, thereby offering significant potential for sustainable agricultural practices. Future research should focus on evaluating silicon's efficacy across a broader spectrum of crops and stress conditions to unlock its full potential in agricultural systems.

Key Words: *Silicon; Plant resilience; Biotic stress; Abiotic stress; Crop productivity*

INTRODUCTION

Silicon, the second most abundant mineral in the Earth's crust, primarily exists as H_4SiO_4. Despite not being classified as an essential mineral for plant growth, its application has been shown to enhance yields in various crops [1]. For instance, combining calcium and silicon foliar fertilizers has proven beneficial for sugar beet production, increasing both biological and sugar yields. Studies have demonstrated that silicon application can significantly boost yields in crops such as potato, rice, sugarcane and canola. Additionally, increased silicon doses have been linked to improved leaf structure. Silicon's role in strengthening cell walls enhances plant resistance to pests and diseases across a range of crops including wheat, rice, maize and vegetables [2,3]. Moreover, silicon aids in mitigating the effects of environmental stresses, such as deficiencies in manganese, cadmium, arsenic, aluminum, zinc and phosphorus, while also bolstering resistance to lodging, diseases and insects [4].

Furthermore, silicon enhances plant resilience to abiotic stresses like drought and salinity. It affects the nutrient composition of plants like sunflowers by increasing the accumulation of both macro and micronutrients. Silicon's presence within plant tissues, particularly in the endoplasmic reticulum, cell walls and intercellular spaces, contributes to overall growth and fertility [5]. Notably, silicon forms complexes with polyphenols, supporting cell wall structure and mitigating the toxic effects of heavy metals. Its presence in specialized cells like bulliform and dumbbell cells strengthens cell walls, enhancing resistance to diseases, pests and lodging, particularly in crops like rice.

Silicon's role as a dynamically active component in activating natural defense mechanisms has been recognized. The mechanisms of silicon transport in plants, particularly in silicon accumulators like rice, have been extensively reviewed. Silicon uptake occurs mainly as monosilicic acid in soil solution, followed by accumulation on the epidermis of various tissues as hydrated amorphous silica. Despite not meeting traditional criteria for essentiality, silicon has been reconsidered as essential due to its role in preventing abnormalities in plant growth and performance. Beneficial effects of silicon include increased photosynthetic activity, enhanced resistance to pests and diseases, reduced mineral toxicity, improved nutrient balance and increased tolerance to drought and frost. These effects vary among plant species and are more pronounced under stress conditions. Overall, silicon stands out for its ability to enhance plant resistance to multiple stresses.

MATERIALS AND METHODS

Fortifying the plant kingdom: How silicon combats abiotic stress

Silicon and physical stresses: Silicon has been identified as a potential protector of plants against radiation-induced injuries. Ma et al., [6] demonstrated that when rice seedlings were subjected to gamma-ray irradiation, those supplied with silicon exhibited a lesser decrease in dry weight compared to silicon-deficient plants, suggesting that silicon enhances rice resistance to radiation stress. Moreover, post-radiation treatment with silicon facilitated faster growth recovery in rice plants compared to those without silicon supplementation. Drought stress, characterized by stomatal closure and subsequent reduction in photosynthetic rates, poses significant challenges to plant growth. However, silicon has shown promise in alleviating water stress by reducing transpiration rates. Ma et al., [6] reported that silicon deposition beneath the cuticle of rice leaves forms a double layer, potentially decreasing transpiration through the cuticle by up to 30%. Interestingly, the beneficial effects of silicon on rice growth were more pronounced under water-stressed conditions compared to non-stressed conditions. Additionally, when rice leaves were exposed to Polyethylene Glycol (PEG), a solution mimicking drought stress, electrolyte leakage from leaf tissues decreased with higher silicon levels, indicating potential membrane protection conferred by silicon [7].

Furthermore, silicon's role in cell water relations, including mechanical properties and water permeability, has been implicated. Leaves containing silicon exhibited higher levels of polysaccharides in the cell wall compared to silicon-deficient leaves, suggesting a link between silicon and cell water dynamics. This association between silicon and water stress alleviation extends to yield components, particularly the percentage of ripened grains in rice and barley, with silicon potentially mitigating water stress effects on grain development.

Silicon deposition in the hull of rice and barley grains, forming a Cuticle-Si double layer, plays a crucial role in reducing transpiration from spikelet's. This deposition maintains a high moisture condition within the hull, which

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IMPACT OF SOCIAL MEDIA IN DIGITAL ERA

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Key Areas:
Huge potential for marketers that implement AI, VR technologies.
Customer engagement behaviors and customer journeys enhanced via SMM.
Importance of ethical practice and explain-ability

Abstract
Academic researchers and professionals in the industry have expressed interest in the growing utilization and efficacy of social media influencers in marketing. This study conducts a systematic literature review utilizing bibliometric-content analysis to map the existing literature where consumer behavior, social media, and influencer marketing are linked, in an effort to shed light on the origins and patterns of this modern phenomena.
The advent of the internet and social media has revolutionized consumer behavior and transformed the business landscape for companies. Leveraging social and digital marketing presents considerable advantages for organizations, such as reduced costs, heightened brand visibility, and increased sales. Nonetheless, notable hurdles arise from negative online word-of-mouth and intrusive brand presence online.
This article synthesizes insights from various eminent experts in the field of digital and social media marketing. Their perspectives offer an intricate narrative on crucial facets of this domain, encompassing artificial intelligence, augmented reality marketing, digital content management, mobile marketing, B2B marketing, electronic word-of-mouth, and ethical considerations.
This research constitutes a substantial and pertinent contribution to both scholars and practitioners alike. It delineates the challenges and opportunities inherent in the field, underscores current research limitations, identifies research lacunae, and formulates questions and propositions aimed at advancing knowledge in digital and social marketing.

Introduction:
Social media influencers have gained immense popularity and wield considerable influence over consumers' attitudes, perceptions, preferences, choices, and decisions. Unlike traditional celebrities or public figures who leverage their established careers (such as actors, singers, or politicians), social media influencers rise from grassroots levels, cultivating an extensive follower base through their online presence on platforms like social media channels or pages.
At the nexus of technology and marketing, social media has emerged as a potent tool for businesses to advertise their products and engage with their target demographic. Its widespread adoption and continuous evolution have significantly reshaped digital marketing strategies. In this article, we will delve into the diverse ways in which social media has revolutionized the digital marketing landscape.
This paper discusses the important potential, difficulties, and future research agenda pertaining to important facets of digital and social media marketing by combining the opinions of numerous top specialists. The paper's observations, which represent the opinions of the invited professionals, span a broad range of digital and social media marketing subjects. The study makes a noteworthy and relevant addition to the body of literature by providing scholars with important new information that will further their understanding of this marketing domain. This subject is presented as a topical addition to the literature, given the maturity of the digital and social media marketing sector and its increasing importance as a keystone of an organization's marketing strategy.
Combining the views of multiple leading experts, this article explores the significant potential, challenges, and research agenda relevant to significant aspects of digital and social media marketing.

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INNOVATIONS IN MULTIMEDIA SERVICES: DEEP-LEARNING ALGORITHM INTEGRATION

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Abstract
Multimedia streaming services have been among the top applications on the internet, due to the vast amount of information presented through it. The advent of the semantic web and the services surrounding it includes many methods of accurately describing multimedia content. This paper investigates the use of a deep learning method to improve the quality of multimedia. Deep learning is a class of machine learning methodologies that uses many-layered artificial neural networks to learn internal representations of data and is showing increasing promise in optimizing multimedia services in complex ways. In the proposed intensification methodology, we integrate Deep Learning algorithms into different multimedia services, particularly focusing on content adaptation techniques such as coding, transcoding, and encryption. Then, we elaborate on how the Deep Learning algorithm can be integrated into coding and transcoding services, which are then followed by how it can facilitate intelligent content adaptation in encryption. Finally, we conducted an experimental comparison between traditional machine learning methods and deep learning methodology to automatically induce a physics simulator to demonstrate great future promise in this field. This comprehensive literature review has revealed that image compression remains uncharted territory for content-based methods, while steady progression has been made in other MIR domains.

Keywords: Multimedia, Deep Learning, Machine Learning, Encryption, Image Compression

1. Introduction

Multimedia streaming services have been among the top applications on the internet, due to the vast amount of information presented through it. The Internet and intranet networks have grown rapidly along with the number of users. Multimedia services are becoming mainstream in both internet and local area networking (LAN) environments. Examples of popular multimedia services are YouTube, Netflix, Spotify, Facebook, and Instagram. These services have revolutionized the way people consume media. Users can stream and acquire information with ease, depending on the connection speed of the network they are connected to. Unfortunately, several types of multimedia consist of high definition and resolutions, which would require a good amount of bandwidth for a user to watch and completely understand the content. High bandwidth usage would eventually lead to congestion while there are a lot of subscribers accessing the multimedia services. Moreover, utilizing mobile networks for accessing multimedia services can incur significant expenses if these services utilize a substantial amount of bandwidth. **(Haile et al., 2021)** Consequently, subscribers may be unable to receive the necessary content due to the limitations of available bandwidth. Similarly, subscribers relying on a local area network would encounter comparable predicaments due to the insufficiency of bandwidth in a shared setting. As a result, subscribers wouldn't be able to

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Maximizing cucumber (*Cucumis sativus* L.) productivity: A study on the influence of transplanting dates, planting density and training techniques in naturally ventilated polyhouses of Himachal Pradesh

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Protected cultivation, sometimes referred to as polyhouse farming, is a common method for creating and preserving a controlled environment ideal for maximum crop productivity. Although protected farming produces crops with less resources than other methods, it still requires a lot of resources. This technology combines production system profitability with quality parameters that are driven by the market. Cucumis sativus or cucumbers, are a highly popular crop grown in naturally ventilated polyhouses in the mid-hills of Himachal Pradesh. This is because the cold temperatures in open fields and shed net houses result in low fruit yield and quality. Cucumbers are a very profitable crop in the early summer because of the high market price. The goal of the current study was to choose polyhouse cucumber hybrids that would be suited for early season harvest in Himachal's mid-hills. Therefore, an experiment was carried out in the off-season at the research farm of department of Agricultural Engineering, college of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya (CSKHPKV), Palampur to study the impact of transplanting date, planting geometry and training system on cucumber productivity under naturally ventilated polyhouse. The experiment was set up using a factorial randomized block design with three replications and it included eighteen treatments i.e., two planting geometries (60 cm × 30 cm and 75 cm × 30 cm), three training systems (two shoots, three shoots and four shoots) and three transplanting dates (1st fortnight of March, 2nd fortnight of March, 1st fortnight of April). Among the date of transplanting, significantly higher vine length, number of fruits per plant, fruit length (18.21 cm), fruit weight (177.86 g), fruit breadth (6.40) and fruit yield per plant (3.23 kg) was recorded under, 1st fortnight of March over 2nd fortnight of March and 1st fortnight of April. Highest fruit length (17.13 cm), fruit breadth (6.34 cm), fruit weight 175.52 g), number of fruits per plant (22.82) and fruit yield per plant (3.10 kg) was recorded under wider spacing (75 cm × 30 cm) than narrow spacing. With respect to the number of shoots per plant, plants with two shoots recorded significantly higher fruit length (17.61 cm), fruit breadth (6.39 cm), fruit weight (179.67 g). Whereas retaining three shoots per plant recorded significantly higher fruit yield per plant (3.48 kg).

Key Words: *Cucumber; Protected cultivation; Polyhouse; Training system; Yield*

INTRODUCTION

Around the world, cucumbers (*Cucumis sativus* L.), a popular vegetable are produced in both open and protected environments. Native to northwest India, cucumbers have been cultivated for at least 3,000 years. Its juice is often recommended as a source of silicon for healthy skin. Cucumbers are rich in minerals like magnesium, potassium, copper, phosphorus and manganese, as well as vitamins A, B, B5, C and K. Enriched in nutritious fiber and antioxidants, including flavonoids and tannins, which safeguard the crop from damaging free radicals and may reduce the chance of developing chronic illnesses. As a thermophilic plant, it prefers temperatures between 18-30 degrees Celsius and is susceptible to cold. Cucumbers are primarily composed of water and they help you stay more hydrated. Ascorbic acid and caffeine, which are also found in cucumbers, help to reduce skin irritation and swelling. Nonetheless, frost sensitivity in the winter months is also a common problem, resulting in damage and hindering productive farming. This restriction has a detrimental effect on the growth and fruit development. Protected cultivation methods in polyhouses have become a practical answer to these problems, providing a regulated environment ideal for crop growth and development [1]. India is a country with a tropical and subtropical climate; the country's year-round high temperatures make it challenging to grow superior grade vegetables in open environments. Protected farming is a unique and specialized form of agriculture where the needs of the plant species being farmed determine how much the microclimate around the plant is controlled. Cucumbers could be grown under protected cultivation to boost the vegetative growth, yield, quality and quantity. Cucumber mosaic virus and other insect pests severely affect seed crops grown in open fields and there is yet no effective control strategy for these pests. Owing to its adaptability and high yield under plastic house conditions, the majority of farmers began cultivating hybrid cucumbers in remote areas during the off-season in order to gain profitable returns. Yields are higher in naturally ventilated poly houses than in open fields. Pest problems related to insects in protected farming differ significantly from those in open fields. Furthermore, choosing the ideal date for transplanting has a significant impact on plant growth and development, which maximizes crop yield and maximizes the use of available land. The production of greenhouse cucumbers highlights the significance of utilizing available space and nutrients to improve yield per unit area through suitable crop density. Previous studies have demonstrated the effects of appropriate row spacing on crop yield and growth. Moreover, spacing influences not only plant characteristics, but also insect and weed interactions, disease susceptibility, soil conditions, germination and emergence.

Training approaches differ according to different plant densities, growth trends and cultivars of cucumbers. By implementing unique training systems, plants are better able to obtain the necessary sunshine, which in turn creates a favorable micro-environment and reduces the possibility of fungal and insect-related problems. In greenhouse cucumber cultivation, manipulating canopy structure through appropriate spatial arrangements-achieved through strategic training-emerges as a critical management strategy for producing desired and marketable yields. Therefore, the main issue with growing cucumbers in open fields is climate change; nevertheless, in protected environments, where the crop's microclimate is regulated, yield is increased. Thus, in order to help farmers in Himachal Pradesh's mid-hill regions during the off-season, the current study was conducted to examine the effects of planting geometry, training systems and transplanting dates on the growth behavior and fruit development parameters in cucumbers grown in naturally ventilated polyhouses.

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Bio-control emerges as a novel and environmentally sustainable method for mitigating soil-borne plant pathogens

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Soil-borne diseases pose significant threats to crop yields and agricultural economies worldwide. Consequently, effective crop protection strategies are vital for sustaining agricultural productivity. Historically, the reliance on chemical fungicides has been prevalent to enhance crop yields. However, the indiscriminate use of these chemicals has led to detrimental effects on the environment, human health and overall ecosystem balance by unintentionally harming non-target organisms. In response to these challenges, alternative approaches have gained traction in recent years for managing soil-borne diseases. Among these alternatives, biocontrol emerges as a promising eco-friendly solution, mitigating the risks associated with chemical residues on human health and the environment. Biocontrol Agents (BCAs) offer a less toxic and more flexible alternative to chemical pesticides. These agents exert their effects through various mechanisms, including antibiosis, competition for resources, parasitism and the Induction of Systemic Resistance (ISR). Bacteria such as *Bacillus* spp., *Pseudomonas* spp. and fungi like *Trichoderma* spp. are widely recognized as effective bio-control agents against soil-borne diseases. Notably, bacteria such as *Bacillus* spp. and *Agrobacterium* radiobacter thrive in soil and the rhizosphere, making them particularly suitable for agricultural applications. This review emphasizes the intricate interactions among soil-borne pathogens, their natural antagonists, plants and the environment, with a focus on fostering sustainable agricultural practices. However, successful implementation of biocontrol strategies requires appropriate management approaches tailored to specific agricultural ecosystems, ensuring their efficacy and sustainability in the long term.

Key Words: *Biocontrol; Systemic resistance; Rhizosphere; Ecosystem*

INTRODUCTION

Soil-borne pathogens are responsible for a decline in yield, quality of products; contaminate food grains and other economic parts of the plant with harmful toxic chemicals and causing great economic losses [1]. *Pythium* spp., *Rhizoctonia* spp., *Fusarium* spp., Phytophthora spp., *Xanthomonas* spp. and *Pseudomonas* spp. are the most common pathogens of soil affecting most of the crops and causing various diseases like root rot, leaf fall, wilting, damping-off, blight, canker, etc., in plants. Due to climate change these plant pathogens are becoming more aggressive, breaking the plant resistance to various germplasm and predominantly cultivated varieties and inhibit the crop to reach its optimum yield. The current practices for management of these diseases are mostly based on host plant resistance and synthetic chemicals. The continuous overuse of these chemicals like pesticides, insecticides, herbicides and fertilizers in agriculture for controlling diseases directly effect on the health of consumers, disturbing the food chain and food web, biomagnifications of chemicals and economic losses to any country by increasing the cost of food products and other side effect have raised a serious alarm [2,3]. Food grains are important for consumers and to prevent it from the contamination of chemicals, a new approach "biocontrol" has been used in agriculture. The Biocontrol Agents (BCAs) refer to the organism responsible for inhibiting or prevent the growth and development of other harmful pathogens. Some of plant growth-promoting rhizobacteria are studied and used in managing soil-borne diseases in plants as they reduce diseases by acting as biocontrol agents [4]. Biocontrol encompasses a diverse array of eco-friendly microbes, offering a rich source of biologically active compounds. These microbes have the remarkable ability to coexist in the environment as non-dominant species while effectively suppressing plant pathogens. Leveraging biological control serves as a sustainable approach to managing plant pathogens, fostering a deeper understanding of the intricate interactions among pathogens, plants and the environment in the pursuit of sustainable agriculture [5].

METHODOLOGY

What are biocontrol agents?

The term 'biocontrol' have used in several areas of biology, especially in plant pathology and entomology. The biocontrol in which the living organism such as bacteria, fungi, nematode or predatory insect those suppresses the growth and development of other organism populations. The term biocontrol agents apply to the use of microbial antagonists which suppresses the growth of pathogens included mainly host-specific. The microbial antagonist that used to control the soil-borne plant diseases, by making bio-formulations called bio-pesticides. Bio-pesticides are eco-friendly approaches for the control of soil-borne pathogens in peanut by the mechanisms involved in their antagonistic activity (Figure 1).

Initially, a diverse array of microorganisms is gathered and subjected to screening for biocontrol efficacy. Numerous isolates undergo screening to pinpoint a disease-suppressive strain (illustrated as a yellow rod). However, it's improbable for this strain to exhibit effectiveness across various conditions. A strategy for identifying new strains that collectively demonstrate efficacy across diverse conditions involves unraveling biocontrol mechanisms and discovering additional biocontrol agents sharing these mechanisms. Genetic analyses can unveil biocontrol mechanisms, such as the role of antibiotic X in biocontrol mechanism. Understanding these mechanisms and the associated genes can facilitate the development of nucleic acid probes tailored to identify new strains with identical biocontrol mechanisms, as depicted by a probe for gene *antX*. Despite sharing similar biocontrol mechanisms, strains harboring antX may exhibit genetic diversity in significant aspects. This diversity enables some new strains to be effective on different crops across various geographic regions or as part of genetically diverse mixtures. This approach facilitates the identification of extensive collections of disease-suppressive strains, bypassing the necessity to replicate the extensive research [6].

The function of prospective bio-control agents in management of soil-borne pathogens

Soil-borne pathogens survive in soil as soil inhabitants and saprobes, widely distributed depend upon the cropping and production practices. Soil with poor irrigation facilitates allow the growth of several soil-borne pathogens which included mainly fungal pathogens like *Phytophthora*, *Pythium* while, *Fusarium* and *Verticillium* wilt occur more frequently in damp soils rather than in dry soils [7]. The usage of Plant Growth-Promoting Rhizobacteria

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Cultivation of tomato, capsicum and cucumber under protected cultivation: Extensive analysis

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Yadav MK, Kumar S. Cultivation of tomato, capsicum and cucumber under protected cultivation: Extensive analysis. AGBIR. 2024;40(2):988-990.

Protected cultivation is a method of growing crops in a controlled environment, allowing for the regulation of factors such as temperature, humidity and light based on the specific requirements of the crop. The overall production is increased and healthier plants are encouraged in this regulated environment. Protected farming methods come in a variety of forms, such as plastic tunnels, raised beds, trellising, mulching, insect-proof net homes, naturally ventilated polyhouses, insect-proof net houses and shade net houses. These techniques can be applied singly or in combination to develop a good growth environment that protects plants from extreme weather, lengthens the growing season or permits the production of crops during the off-season. Tomato, capsicum and cucumber protected culture is an important technique that can greatly improve crop production quality. It has several benefits, including increased yield, improved quality, extended season and defense against pests and unfavorable weather.

Key Words: *Protected cultivation; Tomato; Capsicum; Cucumber; Yield*

INTRODUCTION

Vegetable crops grown under protection is a novel technique that guarantees the production of vegetables of superior quality. This method creates a controlled environment that protects crops from harmful weather, pests and diseases by using buildings like greenhouses, polytunnels and net houses. Vegetable growth conditions can be optimized using this method's exact control over temperature, humidity and light [1]. These days, forward-thinking farmers are growing high-value vegetables and flowers under commercial protected cultivation [2]. In comparison to open fields, shielded structures yield more flowers and vegetables and also have higher output. These configurations produced larger net and gross profits when compared to open settings. Most farmers use open-field cultivation methods, but because these methods don't provide the right temperature, humidity and other conditions, they eventually lower land value, water availability and farmer revenue. Thus, in terms of enhancing agricultural production, soil fertility, profitability and sustainability, among other aspects, protected structures-based farming (also known as protected cultivation) technology is superior than open field agriculture/conditions [3]. Because agriculture still has economic value due to increasing production levels, protected technologies are opening doors not only for higher level growers but also for smaller-scale growers. Protected cultivation can be thought of as a kind of precise, progressive, parallel agriculture that involves almost every aspect of agriculture but is subject to extra examination for technical applicability to circumstances as well as grower and market economics. A suitable microclimate has been created by greenhouse farming and other forms of controlled environment cultivation, allowing for crop production to occur all year round or only during certain periods of the year as needed. The most advantageous and cost-effective polyhouse technology for India's plains and subtropics is the naturally ventilated, low-cost polyhouse. A greenhouse can be used to grow high-value off-season vegetables such as tomatoes, capsicum, cucumbers, bottle gourds, early cauliflower, coriander, cabbage and others for an extended period of time. In addition to being bug proof, these net buildings offer perfect conditions free from viruses and insects for the development of those vegetables, especially during the rainy season. According to a number of research findings, the production of vegetable crops grown in enclosed environments can rise three to five times when compared to open environments [4]. Numerous horticultural crops, such as the following, can be cultivated under protected cultivation: Vegetables include lettuce, leafy greens, zucchini, melon, tomatoes, capsicum, cucumbers and eggplant [5]. Fruits: According to Granatstein et al., [6], grapes, apple, pear, peach, plum, cherry, strawberry and other berry crops, Flowers: Chrysanthemum, anthurium, lilium, carnations, gerberas and roses [7]. Tomatoes were the first vegetables to be produced in greenhouses out of all the crops. In comparison to other vegetables like cucumbers and peppers, it is very simple to cultivate and when grown under protection, the fruit output is quite great. The three fastest-growing states are Karnataka, Andhra Pradesh and Odisha. The tomato or *Lycopersicon esculentum*, is widely regarded as a "Protective Food" and is sometimes referred to as the "poor man's orange". Tomatoes come in two varieties: Indeterminate or vine tomato and determinate or bush tomato. Indeterminate varieties are primarily utilized in greenhouse settings to optimize crop yield and elevate vegetable quality. As they grow, they continuously generate fruits and flowers along the main stem [8]. Protecting against biotic and abiotic stressors is the primary goal of growing capsicum in covered structures, particularly in the off-season. Despite being extremely profitable, capsicum production in India is still in its early stages of transfer and expansion into farmer's fields. To achieve optimal development, productivity and quality, growing tomatoes, cucumbers and capsicum under protected conditions-such as in greenhouses or polyhouses-requires careful consideration of a number of parameters. It is imperative for farmers to select appropriate cultivars, offer optimal growing conditions, regulate environmental elements like humidity, temperature and sunlight and execute efficient irrigation and nutrient control strategies.

LITERATURE REVIEW

Designs, construction and operation of protected cultivation

Vegetable cultivation in greenhouses is a labor-intensive process that requires meticulous planning and multiple stages of operation to be successful. Whether a greenhouse is located in a desert, the tropics or a moderate climate, its design changes accordingly [9]. The earliest greenhouses were highly controlled because it was impractical to grow vegetables in freezing temperatures [10]. In contrast, simpler greenhouses offered minimal climatic control and contributed to the production of an economically viable yield of vegetable crops [11]. Glasshouses are more popular in temperate climates around the world, but greenhouses also give a "windbreak effect" and "shading effect" in other subtropical and tropical areas. While the temperature and humidity within a greenhouse create a "oasis effect" in dry locations relative to the scorching, dry heat outside, rain shelters are the typical protective constructions in wet tropical regions to prevent flooding [12]. Protected cultivation buildings come in a range of forms, from basic net

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ANTECEDENTS AND OUTCOMES OF IMPROVED ENGAGEMENT IN B2B ONLINE COMMUNITIES (BUSSINESS TO BUSSINESS BUYING BEHAVIOUR)

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Abstract
The article provides a framework for the role of online communities in Industrial buying process. The study draws upon existing literature related to the industrial buying process and its linkages with online communities. In the article, knowledge self-efficacy, Self-identity verification and community identification, as characteristics of buying centre members (Users, Buyers, Sellers, Influencers, Deciders, and Gatekeepers), were identified as antecedents of improved engagement in B2B online communities. The article also studies the influence of improved engagement on industrial buying structure, processes and outcomes. The framework, thus proposed, will help B2B marketers use online communities effectively in industrial buying processes.

Keywords
Online communities; Industrial buying process; Knowledge self-efficacy; Self-identity verification; community identification.

Introduction

Prior research shows that Business-to-business (B2B) marketers differ from business-to-consumer (B2C) marketers in buying behaviour, resulting in different promotional procedures (Jussila et al. 2014). B2B marketers do not use online communities extensively, as being used by B2C marketers (Simmons et al. 2010). Thus, B2B marketers are dispossessed of multiple benefits of using online communities. These benefits include customer satisfaction and loyalty (Brodie et al. 2013), new product development (Nambisan et al. 2007), buying behaviour (Algesheimer et al. 2006), and brand building (McAlexander et al. 2002). This advocates that improved usage of online communities has the capability to benefit B2B marketers.

The study's primary purpose is to develop a framework that integrates antecedents and outcomes of improved engagement in online B2B communities. This is particularly appropriate in the age of fast-emerging social media (SM) and online communities (OLCs). The paper is structured in the following way: the literature review stipulates differences between B2B and B2C marketing, and then characteristics of online communities. This is followed by a discussion on the applicability of identified antecedents on improved engagement in B2B online communities. Subsequently, effects of engagement on industrial buying structure, process and outcome have been discussed. The last part of the paper provides the implication of the study for researchers and managers.

B2B vs B2C Marketing

Both B2B and B2C marketing are based upon basic guiding principles of marketing. However, the applicability of these principles deviates in degree. The differences between B2B and B2C purchase behaviour require different marketing communications. B2B and B2C marketing have the following differences. Number of buying influences: Jussila et al. (2014) posits that B2B marketers must frame different messages and communicate through different media to each decision-maker involved in the buying. Slower decision-making: Garber et al. (2002) states that B2B marketers are required to monitor the progress of customers through the lengthy buying process. High-value exchange: As per Garber et al. (2002), B2B buying are of higher value than B2C. High customer engagement: Jussila et al. (2014) states that high customer engagement and vast information exchange occur in B2B buying. Rational decision-making process: Cooper et al. (1988) posits that B2B buying is less stringent than B2C buying. Complex products: As per Jussila et al. (2014), B2B products are more complex, thus require more exchange of information. Technically capable customers: As per Jerman et al. (2012), B2B

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Justice Delayed: Investigating the Causes and Consequences of Pending Legal Casesin India[1]

Introduction

Delving into the intricacies of judicial systems, one is often confronted with the profound maxim, "Justice delayed is justice denied." This age-old adage encapsulates the essence of timely legal recourse for those who have suffered injustices. It underscores the imperative of swift legal proceedings to mitigate the prolonged agony of individuals awaiting resolution. In the labyrinth of legal frameworks, this axiom resonates deeply, serving as a clarion call for reformers and policymakers to address the systemic inefficiencies that impede the expeditious delivery of justice. Against the backdrop of India's independent judiciary, characterized by its federal structure, this investigation endeavors to unravel the underlying causes and ramifications of pending legal cases.

India boasts an autonomous judicial system characterized by a federal structure, which forms the backbone of its legal framework. At its apex lies the revered institution of the Supreme Court, often referred to as the final arbiter of justice. Comprising 33 judges and the Chief Justice of India, this esteemed body holds the mantle of safeguarding the nation's legal integrity. Notably, the Chief Justice, colloquially known as the "master of the roster," orchestrates the court's proceedings, albeit devoid of veto powers.

Following the Supreme Court in precedence is the esteemed network of High Courts, serving as the pinnacle of judicial authority within each state. These courts, under the stewardship of their respective chief justices, ensure the administration of justice at a regional level. With 24 such High Courts dispersed across the nation, they wield considerable influence in upholding legal sanctity.

Lastly, nestled within the judicial hierarchy are the District Courts, also known as Subordinate Courts. Governed by district and session judges under the vigilant oversight of the High Courts, these tribunals cater to the grassroots level of justice delivery. Split into Sessions Courts and Civil Courts, they serve as vital conduits for adjudicating a myriad of legal disputes.

Both the Supreme Court and High Courts are vested with appellate jurisdiction, thereby serving as vital pillars of the legal edifice. Appeals originating from District Courts ascend to the High Court, and subsequently, to the esteemed corridors of the Supreme Court, culminating in the pursuit of justice at its zenith.

Unknown elements that impede our courts and postpone justice

Judiciary corruption in India

Hidden impediments cast a shadow over the efficiency of our courts, perpetuating the delay in dispensing justice. Chief among these is the specter of corruption that haunts the corridors of the Indian judiciary. The ethical integrity of the system comes under scrutiny as instances of malfeasance emerge, potentially undermining the very foundation of justice. Corrupt practices among judges, characterized by the deliberate withholding of judgments or the granting of biased adjournments, serve to exacerbate the backlog of cases. Personal biases and vested interests may taint the impartiality of judicial proceedings, tilting the scales of justice in favor of the privileged few.

Analogous to a cobweb ensnaring unsuspecting prey, the Indian judicial system becomes entangled in its own complexities, leaving justice delayed and, consequently, denied. Small grievances, akin to hapless insects, become ensnared within its intricate threads, while the powerful perpetrators evade accountability, akin to the larger insect that effortlessly breaks free. This stark juxtaposition underscores the pervasive nature of corruption within the system and its detrimental impact on the pursuit of equitable justice.

The cash at doorstep case:

In a notable case, retired High Court Judge NirmalYadav was implicated for allegedly receiving a sum of Rs. 15 lakh from Delhi businessman Ravinder Singh in 2008. Initially, this substantial amount was mistakenly delivered to the Chandigarh residence of Justice NirmalYadav, who was then serving

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RNB Global University Registrar Bikaner

REVIEW ARTICLE

Management of arid fruit crops in saline environment: A review

B. D. Sharma, R Bhargava, Bankey Lal*, Ravi Kumar

Sharma BD, Bhargava R, Lal B, et al. Management of arid fruit crops in saline environment: A review. AGBIR.2024;40(2):949-953.

Salinity is the degree of saltiness or the amount of dissolved salt in a body of water or in soil, such as calcium, magnesium and sodium sulfates and bicarbonates salt. The osmotic forces that plants experience when growing in salt marshes or other extremely saline environments are known as stress. One of the oldest environmental and horticultural issues that humans have faced is salinity, which scientists find difficult to address in terms of output and productivity in our nation. Numerous causes contribute to salinity, including high evaporation rates, inadequate rainfall, mineral weathering and improper irrigation water utilization, but canal irrigation has been attributed with the greatest blame. The salt problem affects about 10% of all arable land worldwide. Conventionally, a variety of soil reclamation techniques, including leaching, flooding, scraping, green manuring, etc. are employed to lessen the disease. Due to soil salinity, crop yields have decreased by up to 50% and as a result, many places have stopped farming. Depending on the issue, extra soluble salts may be eliminated by subterranean drainage, flushing and leaching or scraping the salt crust on the surface. The capacity of crops to withstand salinity at different growth stages varies as well. The germination and early stages of most crops that get saline irrigations are often the most susceptible and as the crop ages, so does its tolerance. Important solutions for crop production in saline soils include salt-tolerant cultivars and other methods of managing arid fruit crops on saline soils.

Key Words: *Soil salinity; Manuring; Arid fruit; Irrigation water, Environment*

INTRODUCTION

Sodic or saline soils make up around 10% of the 7000 Mha of arable land on Earth of the 1500 hectares of arable land, 23% are salty and the remaining 37% are sodic. These soils have high pH, low permeability, low infiltration rate and poor physical condition, all of which contribute to the plant's steady decline in growth and limited ability to produce lateral shoots [1,2]. There were also fewer leaves and fruits, as well as a decrease in the fresh and dry weight of the plant parts. Generally speaking, leaves get thicker than usual. More repressed than the root growth was the top growth. Plants are impacted nutritionally and ultimately physiologically by elevated sodium salt levels. Produce losses are greater in fruit crops. Sodic soil found extensively in the states of Haryana, Punjab and Uttar Pradesh [3].

The main issues in the country's dry and semi-arid regions are salinity and sodicity. Approximately 7 million hectares of salt-affected soils exist in India, with a significant portion of these being in Rajasthan. In dry and semi-arid regions of India, ground water is the most important source of supplemental irrigation; yet, a sizable portion of them in north India are brackish or salty (Uttar Pradesh, 43%, Haryana, 55%, Rajasthan, 68%). In coastal regions, western Uttar Pradesh, Haryana, Punjab, Rajasthan, Gujarat and other places, saline soils are common. The problem of soil salinization and sodification has been caused by their careless and careless use, which disregards their salt concentration and composition in relation to soil type, crop, climate and management practices [4-6]. This has affected crop yields and made the general public doubtful of their usefulness as an additional source of irrigation. Thankfully, research into the management of salt-affected soils and saline water has advanced, demonstrating that the majority of waste land and saline water can be used productively as long as the fundamentals of soil-water-plant relationships are correctly understood and applied sparingly [7]. A sizable portion of Rajasthan has been affected by the issue of salt infestation brought on by the usage of saline fluids for irrigation. For development of saline soils several factors are responsible some of them are listed below:

- Gradual withdrawal of ocean water and mineral weathering are chief factors responsible for salinization.
- Use of irrigation water also, faulty irrigation methods.
- Poor soil drainage, in sufficient water supply and rise in ground water table.
- More evaporation of water in arid/semi-arid region.
- Canal irrigation has been held more responsible.

In view of the high population pressure, the country has to put more area for production of cereals, pulses, oil seeds, etc. hence it is rather difficult to get good piece of fertile land for fruit cultivation. Under such circumstances, proper utilization of the salt affected soils offers a unique opportunity of bringing additional area under fruits for improving the ecosystem and national economy of the country. Fruits have special significance to human beings as a protective nutritional food. The yield and income per unit area are much higher as compared with cereals and many forest trees [8,9].

LITERATURE REVIEW

Quality of irrigation water

In order to manage irrigation effectively, information regarding the quality of irrigation water should be obtained prior to planting any fruit crops. Depending on the level of restrictions, irrigation waters can be generically classified as either good or saline alkali fluids. Two classes of low quality water have been further divided into three homogeneous subgroups each. (Table 1).

TABLE 1

Classification of different types of poor quality waters

Water quality	EC (dSm-1)	SAR (mmol/l)1/2	RSC (meL-1)
A. Good waters	<2	<10	<2.5
B. Saline waters	-	-	-
(i) Marginally saline	2-4	<10	<2.5
(ii) Saline	>4	<10	<2.5
(iii) High Sodium Adsorption Ratio (SAR) saline	>4	>10	<2.5
C. Alkali waters	-	-	-
(i) Marginally alkali	<4	<10	2.5-4.0
(ii) Alkali	<4	<10	>4.0
(iii) Highly alkali	<4	>10	>4.0

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RNB Global University Registrar Bikaner

REVIEW ARTICLE

A review on medicinal properties and nutritional security of Okra

Vipul Pratap Singh[1], Bankey Lal[2*], Surabhi Sharma[3], Arun Kumar Verma[1]

Singh VP, Lal B, Sharma S, et al. A review on medicinal properties and nutritional security of Okra. AGBIR.2024;40(2):949-953.

There has been a recent paradigm shift away from traditional medicine and toward relatively safer phytotherapies. This discrepancy is important for the treatment of various chronic disorders. Okra (Abelmoschus esculentus L.) is a popular vegetable crop with great nutritional value and therapeutic effects, making it a potential option for use in a variety of nutraceutical products. The okra fruit's mucilage, seeds and pods are all rich in particular essential bioactive components that give it its medicinal qualities. The potential therapeutic effects of okra's phytochemicals on a number of chronic illnesses, such as type 2 diabetes, heart disease and digestive issues, have been studied. Their antifatigue, liver detoxifying, antimicrobial and chemo preventive qualities have also been investigated. Most people agree that okra is a cheap, easily accessible vegetable crop with a variety of nutritional benefits and possible health benefits. Despite a plethora of studies on okra's medical benefits and possible nutraceutical relevance, research on its pharmacokinetics and bioavailability has been lacking, which has hindered its broad use in the nutraceutical industry. This study compiles the research on the bioactive ingredients of okra and its possible application as a nutraceutical. It will also lay the groundwork for future research into the pharmacokinetics and bioavailability of okra in advance of its possible commercial manufacturing for use as a remedy for various chronic illnesses.

Key Words: *Antidiabetic; Cardio protective; Functional foods; Nutraceuticals; Okra; Phytotherapy*

INTRODUCTION

Okra (Abelmoschus esculentus L.) a member of the Malvaceae family, is also referred to as lady's finger in many regions of the world where it is grown. Okra is also known by the following common names: Gombo, hamia, okra, quimgombo, lai long ma, and jain et al., [1]. It is believed that okra originated in or around Ethiopia, where it was widely cultivated by Egyptians in the 12th century. It then extended to North Africa and the remainder of the Middle East [2,3]. Growing yearly, okra is a common crop for gardens and farms, mostly in tropical and subtropical regions of the world. It is a popular food crop that is well-known for its flavor all over the world. The young green pods of okra are usually consumed as vegetables, but the extract from the pods can also be used to soups and sauces to make them more viscous [4,5]. Another important application of okra fruit is its extensive use in the pickle business. Because of their numerous health benefits and long shelf lives, polysaccharides, which are found in okra, are used in baked goods and sweetened frozen foods like ice cream [6]. Tiny, soft, hairy structures cover the anatomical surfaces of the fruits, stem and leaves of okra. The ability of okra plants to flower is perennial, although it is highly dependent on a range of biotic and abiotic factors. Okra has hairy coverings on both the upper and below surfaces of its leaves, which are polymorphous and petioles that are around 15 cm long. Blooms of okra are easily recognized by their somewhat yellowish color with a red center. The capsule or pod, that contains the edible part of okra is pentagonal, pyramidal-oblong and ranges in length from 15 to 20 cm. Okra pods have been used historically for food, as an aphrodisiac as an astringent and as a hunger stimulant. Additionally, okra pods have been proposed as a treatment for urinary tract issues, diarrhea and gonorrhea [7].

It has also been demonstrated that extracts from young okra pods have moisturizing and diuretic properties and that the plant's seeds contain fungicidal and anticancer properties [8]. Due to the presence of several important bioactive compounds and their associated bioactivities, okra has recently been used for its nutritional benefits as well as its nutraceutical and medicinal qualities. This study examines the nutritional value of okra, talks about the possible therapeutic applications of its bioactive ingredients and considers the vegetable's potential for use in the production of functional foods and nutraceuticals. The potential health advantages of okra-based nutraceuticals and their use are among the main topics of this review, as are the medicinal applications of Abelmoschus esculentus as a nutraceutical plant.

LITERATURE REVIEW

Okra's nutritious and bioactive ingredients

It can be argued that okra is a more effective nutritious element than a staple crop. Small enterprises in Hunan, China and Surajbala Exports Private Limited, New Delhi, India, have utilized okra seeds to extract oil. Additionally, one of the most important variables in assessing a food's nutritional value is its lipid content. The lipid composition of different food types varies in terms of the quantity of lipids such as diacylglycerols, triacylglycerols, polar lipids and free fatty acids. Among these elements that are crucial in determining the durability and nutritional worth of different food types are fatty acids. Triacylglycerols are biomolecules made up of both unsaturated and saturated fatty acids, with only minor variations in the number of associated acyl group repeats, the number of double bonds repeated and their locations. Importantly, these lipids are destined to serve as energy stores by nature [9]. Prior to this, Savello et al., [10] found that the okra plant's seeds are a significant source of oil, making up 20 to 40% of the total composition depending on the extraction method. Linoleic acid, a well-known Polyunsaturated Fatty Acid (PUFA) representative, makes up the majority (47.3%) of the oil in okra seeds. Additional important nutritional components required for human growth are the amino acids and their polymers or proteins [11,12]. Okra seeds are said to have a different protein composition than grains and pulses because the balance of unique amino acids, particularly lysine and tryptophan has been added to the protein components. Due to their high content of essential amino acids, okra seeds are an essential component of the human diet [13]. Okra also provides a possible excess of carbohydrates and vitamins, two other important nutritional components. In addition to being popular for their excellent nutritional value, okra pods can be eaten raw or cooked [14]. Table 1 lists the nutritional benefits of each edible portion of the okra plant (per 100 g serving).

Additionally, okra provides an abundance of nutrients that are necessary for maintaining good cellular balance. There is proof that the parts of plants that are edible have different amounts of calcium (Ca), phosphorus (P) and iron (Fe)-84, 90 and 1.20 mg, respectively. It also includes beta-carotene, riboflavin and vitamin B complex in approximate amounts of 185 g, 0.08 mg and 0.04 mg, respectively. The extra vitamins that are present in okra plants are listed in Table 2.

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RNB Global University Registrar 949 Bikaner

REVIEW ARTICLE

Lettuce: A dive into its nutritional value and economic significance

Bankey Lal[1]*, Sunita Bhandari[1], Ashutosh Upadhyay[2], Pranjal Singh[2], Vipul Pratap Singh[2]

Lal B, Bhandari S, Upadhyay A, et al. Lettuce: A dive into its nutritional value and economic significance. AGBIR.2024;40(2):954-956.

Lettuce is a rich source of nutraceutical and pharmaceutical, antioxidants phyto chemicals compounds which are rich in anticarcinogenic properties. It is one of the most well-known green vegetables in the world, lettuce has several purposes outside of food. Customers can select from a variety of varieties in the lettuce category. Furthermore, lettuce is a great source of health-promoting bioactive substances like chlorophyll, carotenoids and polyphenols. In addition, there are differences in the nutrient makeup and antioxidant components of different types of lettuce, particularly between green and red variants. The nutritional value of lettuce is contingent upon its composition, namely its antioxidant content, which can serve as a vitamin. The health advantages are dependent on how they enter the bloodstream and function biochemically. In the digestive tract, certain ingredients may be changed or released from the food matrix.

Key *Words: Lettuce; Economic importance; Antioxidant; Flavonoids; Phenolic acids*

INTRODUCTION

Lettuce (*Lactuca sativa* L.) has chromosome number 2n=18, which places it in the Compositae (Asteraceae) family. Originating from the Mediterranean region, this crop is widely grown for salads worldwide [1]. The Latin word "Lactuca" for milk is the source of lettuce's name, as chopped leaves release a milk-like substance known as sap. Also referred to as "The King of salad crops" it is frequently found in fast food. It grows a short stem at the beginning of the season and the cluster of leaves varies greatly among variations in terms of shape, personality and color. A temperate region's annual crop for the cool season is lettuce. A popular salad crop in North America, Australia and the majority of Europe and South America is lettuce. Consumption and production of lettuce are highest in the USA. China holds the top spot in the global lettuce production rankings, while India grows lettuce in kitchen gardens to supply continental hotels [2].

Since lettuce is a crop native to temperate regions, it requires chilly temperatures to germinate. It may be cultivated satisfactorily at mean temperatures between 130°C and 16°C. When the soil temperature rises above 22°C, seeds do not germinate as intended. The ideal range of temperatures for seed germination is between 18°C and 21°C. The finest soil types for growing lettuce are sandy loam or silt loam; the ideal pH range for commercial production of lettuce is 5.8 to 6.6 [3].

A good source of vitamins A, C and B complex, as well as pyridoxine, riboflavin and thiamine is lettuce. It also offers some protein, carbs, dietary fiber and a negligible quantity of fat. Additionally, lettuce offers elements primarily present in the leaf, such as calcium, iron and copper [4]. Most people eat lettuce raw in salads and sandwiches. In Chinese cooking, the leaves are occasionally cooked as an herb [3].

Typically, it is used shredded in a salad with other salad vegetables including tomato, cucumber, onion and carrot. Chop the fragile leaves and heads and eat them as salad. Moisture (93.4 g), protein 2.1 g, fat 0.3 g, minerals 1.2 g, fiber 0.5 g, carbohydrates 2.5 g, calcium 50 mg, phosphorus 28 mg, iron 2.4 mg, vitamin A 1650 I.U., thiamine 0.09 mg, niacin 0.50 mg, riboflavin 0.13 mg, vitamin C 10 mg and energy 2.1 kcal are all present in one hundred grams of edible lettuce [5].

One of the most popular green vegetables consumed worldwide, lettuce has a number of therapeutic benefits in addition to its economic significance. It is a grade commercially significant salad crop that is available year-round on the market. Lettuce contains various health-promoting and therapeutic components, including flavonoids, phenolic acids and antioxidants [6]. The prevention and treatment of diseases like cancer and heart problems have been studied while using these helpful components for health. Lettuce has anti-inflammatory characteristics that aid in managing inflammation. It is advantageous in lowering the risk of diabetes and enhances bone health and bodily metabolism. Additionally, the antioxidant activity of flavonoids can lower the risk of cardiovascular disease and cancer. Lettuce is a rich source of nutraceutical and pharmaceutical, antioxidants phytochemicals compounds which are rich in anticarcinogenic properties [7]. Due to the bioactive chemicals found in vegetables, eating lettuce has health benefits for people [8]. Consuming vegetables has been linked in certain epidemiological studies to a decreased risk of chronic illnesses such cancer and cardiovascular disease [9]. One of the main natural sources of phytochemicals is lettuce [10]. Bioactive nutritional components, such as glycosylated flavonoids, phenolic acids, carotenoids, vitamin B groups, ascorbic acid, tocopherols and sesquiterpene lactones are essential. Furthermore, the results showed that the plasma redox status of healthy individuals was not changed by consuming lettuce stored in packaging with a modified environment [11]. *Lactuca sativa* has also been shown by various researchers to be effective in treating oxidative damage, cancer, diabetes, Alzheimer's disease and other illnesses [12,13].

LITERATURE REVIEW

Natural antioxidants that have been isolated and identified from plant sources include: Organic fertilizers can be used to improve the quality of leafy vegetables and human health by reducing the amount of toxic substances like nitrates produced by conventional fertilizers in vegetables like lettuce [14]. For agricultural use and ecological balance, organic fertilizers replace inorganic fertilizers. Plant leftovers, livestock manure, farm yard manure and industrial wastes are the main sources of organic fertilizers. Organic fertilizers give lettuce the nutrients it needs to grow, yield more, and improve its quality [15].

In addition to being a protective agricultural input that improves the physical, chemical and biological properties of soil and increases soil fertility, porosity and water holding capacity, vermicompost is a very nutrient-dense organic fertilizer that is more potent than traditional compost at promoting growth. The best way to improve the vegetative development, quality and yield performance of lettuce crops is to use vermicompost. Higher levels of readily available nutrients, such as nitrate and ammonical nitrogen, phosphorus, potassium, calcium and magnesium that are produced from wastes, are found in vermicompost.

Sustainable agriculture and ecologically friendly systems use bio-fertilizers and bio-pesticides, respectively. In addition to chemical fertilizer, biofertilizers offer an inexpensive, sustainable source of plant nutrition.

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RNB Global University Registrar Bikaner

Emerging seed production technologies of potato in India

Vipul Pratap Singh[1], Bankey Lal[2*], Surabhi Sharma[3], Aeshna Sinha[4], Arun Kumar Verma[1]

Singh VP, Lal B, Sharma S, et al. Emerging seed production technologies of potato in India. AGBIR.2024;40(2):980-983.

India, known as the world's second-largest potato producer, understands how crucial good seed is for potato farming. But there are hurdles in the seed production process: high seed rates, slow multiplication, viral infections and problems with storing and moving the seeds. This leads to a lot of edible food being used as seed instead of being eaten and it costs a lot-about 40%-50% of total production expenses. One big issue is that not enough farmers are using newer, better potato varieties because it's tough to get enough good seeds and they have to keep replacing them often. To tackle these problems, scientists are working on faster ways to produce healthy seeds in big batches to meet the demand in India. Around the world, people have been shifting from old-fashioned to high-tech seed production methods since the early 1900s. Especially in hot places, like tropical areas, there's hope that creative ideas can make producing potato seeds easier. In India, there are new ways of making potato seeds that show things are changing. But there are still problems, so it's important to keep researching and improving to overcome them.

Key Words: *Potato; Micro-propagation; Aeroponics; True potato seed; Potato diploids*

INTRODUCTION

India is seeing a rise in the popularity of potatoes (*Solanum tuberosum* L), which account for 11.3% of the world's potato acreage and 12.5% of its total production. India produced an average of 23.77 tons/ha of potatoes during the 2019-2020 harvest season, harvesting about 51.3 million tons from 2.16 million hectares. The creation of improved potato varieties suitable for sub-tropical climates and technological developments have been the driving forces behind the 3.28 and 18.87-fold increases in potato production and productivity in India, respectively, between 1961 and 2020. However, there are still issues with potato production in India. These include a lack of high-quality seed, a lack of different potato varieties with favorable economic qualities for growers and a lack of infrastructure for storage. Crop productivity is directly impacted by inadequate supply of high-quality planting material [1]. The production of seed potatoes and its supply chain face a particular challenge due to the bulky nature of the seeds, high seed rates and sluggish multiplication rates (five to six times). Potatoes degrade quickly due to vegetative multiplication utilizing tubers as seeds, thus it's best to replenish the seeds every year or every two years. Furthermore, because of their high cost, farmers are either unable to afford quality seeds or cannot obtain them in sufficient quantities. The nation's small number of aphid-free, seed-producing locations exacerbates problems associated to seeds. According to studies, using just premium seeds can boost output by 15%-20% [2].

In India, there exists a significant disparity between the demand and supply of certified seed potatoes. Annually, the Central Potato Research Institute (CPRI) under the Indian Council of Agricultural Research (ICAR) produces approximately 2,400 tons of breeder's seed or basic seed. Of this quantity, 80% is distributed to states and other organizations for multiplication purposes. However, the total volume of certified seed generated through the three stages of multiplication-foundation 1, foundation 2 and certified grades-amounts to only around 0.5 million tons. This falls short of meeting the overall seed requirement, assuming a 100% Seed Replacement Rate (SRR), leaving a deficit of nearly 4.9 million tons [3]. Singh et al., [4] illustrate the traditional methodologies employed in seed potato production, involving the generation of breeder's seed after four field multiplications of nucleus seed on ICAR-CPRI research farms. Subsequently, three additional field multiplications are conducted as foundation 1, foundation 2 and certified seed by respective states. However, this conventional system encounters challenges such as low rates of field multiplications, the necessity for a large quantity of disease-free propagules at the outset and the accumulation of degenerative viral infections with each field exposure [5]. Additionally, the breeder's seed provided by ICAR-CPRI often fails to multiply in the three generations recommended by the states.

Approximately 1.2 million tons of properly labeled potato seed are retailed by private seed manufacturers, primarily in Punjab, western Uttar Pradesh, West Bengal and Haryana. Nevertheless, these producers lack the infrastructure and appropriate methodologies to monitor seed quality effectively. Consequently, it becomes imperative to establish a seed production system incorporating advanced techniques to enhance seed quality, diminish field exposures and implement a robust certification and quality assurance framework for seed cultivated and distributed by private producers. This brief overview aims to spotlight ongoing developments in India's seed potato industry.

LITERATURE REVIEW

New developments in the production of seed potatoes

Production of seed potatoes by micro propagation/tissue culture: The integration of micro propagation techniques into commercial seed production has transformed potatoes from laboratory test tubes to actual field cultivation. Initial experiments with tissue culture from potato tubers trace back to 1951. Since then, a wide array of plant tissues from diverse organs including leaves, petioles, internode segments, ovaries, anthers, stems, roots and shoot tips have been successfully cultured [6,7]. The adoption of micro propagation in the production of seed potatoes holds promise for resolving many issues associated with conventional seed production systems [8]. This process typically involves meristem culture to eliminate viruses. To enhance the likelihood of generating virus-free plants, meristem culture is often combined with thermotherapy and/or chemotherapy. Despite meticulous care, obtaining a substantial number of virus-free mericlones is often challenging. Therefore, each mericlone intended for use as a source plant in large-scale micro propagation programs must undergo virus testing

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Effect of Integrated Nutrient Management on Growth and Yield attributing parameters of *Kharif* onion (*Allium cepa* L.)

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ABSTRACT

The experiment was conducted at the Research Farm of the Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur U.P. An experiment was conducted during *Kharif* season in the years, of 2021-22 and 2022-23. The experiment was laid out in randomized block design with three replications. The treatments consisted of T1- Control: T2- 100% RDF (NPK @ 120:60:80 kg/ha; T3- 75% RDF+ FYM 6 t/ha:T4- 75%RDF+ Vermicompost@2 t/ ha; T5- 75%RDF+FYM @ 3t/ha + vermicompost @1 t/ha; T6- 75%RDF + FYM @ 3t/ha+ Vermicompost @ 1t/ha+ Biofertilizer (*Azotobacter* +PSB @5kg/ha each) : T7 - 50% RDF + FYM @ 12t/ha; T8- 50%RDF + Vermicompost @ 4t/ha: T9- 50%RDF+ FYM @6t/ha + Vermicompos @ 2t/ha:T10 - 50%RDF + FYM @ 6t/ha + Vermicompost @ 2t/ha+ Biofertilizer (*Azotobacter* + PSB @ 5kg/ha each).Results revealed that the treatment T10 (50% RDF +FYM @ 6 t/ha + Vermicompost @ 2t/ha+ Biofertilizer (Azotobacter + PSB @ 5kg/ha each), performed better with respect to growth characters such as maximum values for plant height at 90 DAT, number of leaves per plant at 90 DAT, length of leaf at 90 DAT, and yield contributing characters, *viz* Polar diameter, Equatorial diameter, neck thickness of bulb.

Key words: INM, Growth, Yield, Biofertilizer, Vermicompost, Farm yard manure

Introduction

Onion (*Allium* cepa L.) belongs to the family Alliaceae. *Allium* the most important cultivated species are onion (*Allium* cepa L.), Leek (*Allium ampeloprasum* L.), Japanese bunching onion (*Allium fistulosum* L.). Onion is one of the most important vegetable and spice crop grown in temperate, subtropical and tropical climates throughout the world. Onion exhibit particular diversity in the Eastern Mediterranean countries, through Turkmenistan, Tajikistan to Pakistan and India, which are the most important sources of genetic diversity and believed to be center of origin. India is one of the leading onion producers with production of 2362.33 thousand MT per year from an area of 1284.99 thousand hectare, with the productivity of 18.10 MT/ha (Horticulture Statistics Department, 2018-19). The basis for

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संग्रथन

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Appropriateness of Job Redesign versus Job Enrichment in Today's Transforming Corporate Culture

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Abstract:

As organizations evolve to meet the demands of a rapidly changing business landscape, the way jobs are designed and enriched has become a focal point for maximizing employee engagement, satisfaction, and productivity. This research paper examines the appropriateness of job redesign and job enrichment in today's transforming corporate culture, exploring their respective benefits, challenges, and impact on employee motivation and organizational performance.

Key Words: Job Redesign, Job enrichment, motivation, job satisfaction, etc.

Introduction:

In today's transforming corporate culture, the appropriateness of job redesign versus job enrichment depends on various factors such as the nature of the organization, the type of work, and the preferences of the workforce. Both approaches have their advantages and can be used effectively depending on the goals and needs of the organization.

Job redesign and job enrichment are two approaches used by organizations to enhance job satisfaction, performance, and employee engagement. While both aim to improve the overall quality of work, they differ in their focus and implementation.

Job Redesign:

Job redesign involves restructuring existing job roles to make them more meaningful, efficient, and aligned with organizational goals.The primary goal of job redesign is to increase productivity, employee motivation, and job satisfaction by modifying tasks, responsibilities, and work processes. Job redesign can include task variety, task significance, autonomy, and feedback. It may involve combining tasks, expanding job roles, or redesigning work processes.It can lead to increased employee engagement, improved job performance, reduced turnover, and enhanced organizational effectiveness. Also implementing job redesign may face resistance from employees accustomed to their current roles. It may also require significant changes to organizational structures and processes. Some considerations for the appropriateness of each approach:

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STABILIZING THE APPREHENSIONS OF CORPORATE GOVERNANCE AND COMPLIANCE: A NEED OF AN HOUR

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Abstract:

Acknowledging that despite significant obstacles, Indian civilization has been steadily developing for thousands of years, Prime Miniter Mr. Narendra Modi stated that "the biggest aspect of our society is the tendency to improve itself internally while moving forward on the path of progress."
By extending the thought, business today is growing in a much of the complex and turbulent times, which is full of uncertainty. Corporates requires a way through which important activities can be managed effectively and efficiently. To manage the corporate governance in the organization, they must integrate the conventional management practices in a disciplined way to attain the employee effectiveness, improving business process and other important concerns of the business. Earning this effectiveness, it is significant to understanding the apprehensions or concerns of the corporate governance and compliance. The chapter will discuss about understanding the corporate governance apprehensions as well as concerns of compliance standards and trying to achieve the balance between the two for the smooth working of the corporates.

Manuscript:

1 Introduction:

To succeed in a constantly changing world, individuals and firms must comprehend how corporate settings are altering. Technology is transforming corporate operations at a rapid pace. Cloud computing, data analytics, automation, and artificial intelligence are being adopted, which is changing procedures, allowing remote work, and improving consumer experiences. Disruptive technology and new competitors can quickly alter the competitive environment. Businesses must encourage creativity and be willing to investigate novel business concepts. The environmental and social impact of a firm is becoming increasingly important to stakeholders, such as investors and customers. Corporate plans increasingly incorporate sustainable practises and ESG factor reporting. Now a days businesses must encourage innovation and be willing to consider trying out novel business strategies.

Corporate executives and professionals must be flexible, forward-thinking, and willing to learn and adapt in order to successfully navigate these turbulent times. They must to be abreast of market developments, make investments in the training of their workforce, encourage creativity, and have a well-defined plan in place for dealing with environmental and societal issues. It's also critical to understand and abide by the constantly changing legal environment with regard to sustainability reporting and data protection.

There has been much discussion over the years about the importance of eliminating outdated, traditional laws and making sure that the general public receives justice in a timely and reliable manner. He continued, saying that every society's judicial system, customs, and other practises have evolved to meet the demands of the day. Declaring that despite significant obstacles,

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SOCIAL DYNAMICS OF WINTER VEGETABLE CONSUMPTION: EXPLORING NUTRITIONAL VALUE AND COMMUNITY HEALTH

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Abstract
This review synthesizes findings from nutritional science and sociocultural studies to illuminate the multifaceted significance of winter vegetables. Examining the macro and micronutrient composition alongside socio-economic and cultural contexts, we uncover the intricate relationship between winter vegetables and human health. Winter vegetables, often overlooked in social-science discourse, serve as crucial components of dietary patterns and cultural practices worldwide. Winter vegetables, particularly those grown in colder climates, are a vital part of a balanced diet, providing essential nutrients such as vitamins, minerals, fiber, and antioxidants. These vegetables play a crucial role in maintaining health, preventing chronic diseases, and promoting optimal bodily functions. Vitamins like vitamin A, vitamin B, vitamin C, and vitamin K are essential for vision, immune function, and skin health. Minerals like potassium, magnesium, and iron are essential for various physiological functions. Leafy greens, cole crops, bulb crops and root vegetables are rich in antioxidants and phytochemicals that protect cells from oxidative stress and inflammation. Regular consumption of these vegetables can reduce the risk of chronic diseases. This review offers a holistic understanding of winter vegetables' role in promoting health and well-being within diverse social and cultural contexts.

Keyword:
Winter vegetables, vitamins, minerals, antioxidant social and cultural contexts.

Introduction:
India is 2nd largest producer of vegetables in world occupying an area of 10.1 million hectares with the production of 209.14 million tones (Anonymous 2022). Winter vegetables, hardy and nutrient-rich, thrive in colder climates, offering vital nutrients during the chilly season. With so many vital components that support general health and wellbeing, vegetables are a crucial component of a well-balanced and nutrient-rich diet. Vegetables, which are abundant in vitamins, minerals, fiber, and antioxidants, are essential for avoiding chronic illnesses and fostering healthy body processes. The most affordable and easily accessible sources of vital fibers, vitamins, minerals, necessary amino acids, and compounds that specifically aid in disease prevention are found in vegetables (Kumar *et al.* 2020). We will examine the wide range of nutrients present in vegetables in this thorough investigation, illuminating both their individual advantages and the combined effects they have on human health. Vegetables are a great source of different vitamins, each of which has a special function in preserving health. Carrots, sweet potatoes, and spinach are good sources of vitamin A, which is important for skin health, immunity, and eyesight. Vitamin C is a potent antioxidant, strengthens the immune system, and promotes the creation of collagen. It is found in large amounts in citrus fruits, bell peppers, and broccoli. Vitamin K is necessary for healthy bones and blood clotting, and dark leafy greens like kale and Swiss chard are great suppliers of this vitamin. Vegetables are a rich source of minerals, which are necessary for a number of physiological processes. Iron-rich leafy greens, including spinach and kale, help the blood's oxygen delivery system. Tomatoes, sweet potatoes, and bananas are rich in potassium, which is essential for preserving a good blood pressure level. Green leafy vegetables like spinach and Swiss chard are rich sources of magnesium, which is necessary for healthy muscles and nerves. Rich in nutritional fiber, vegetables support healthy digestion and help ward off ailments like constipation. By promoting satiety and lowering total caloric intake, fiber also aids in weight management. Vegetables rich in fiber, such as broccoli, Brussels sprouts, and peas, boost intestinal

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Effects of plant growth regulators on the production of vegetables

Mahendra Kumar Yadav[1]*, Juri Das[2]

Yadav MK, Das J. Effects of plant growth regulators on the production of vegetables. AGBIR.2024;40(2):984-987.

Significant research on vegetable production has focused on the effects of plant growth regulators. Review demonstrates that using the right plant growth regulators can help increase vegetable production. They play a critical role in early planting, sex modification, yield and quality enhancement, resistance to pest illness, plant growth regulation, postponing senescence to prolong plant productive life and are essential steps in guaranteeing vegetable production. Nonetheless, Plant Growth Regulator (PGR) effectiveness is determined in part by several factors, including the specific type of regulator, the targeted vegetable crop and environmental conditions. Sustainable and responsible use of PGRs is crucial to minimize environmental impact and ensure economic viability. PGRs are essential resources for growing vegetables, enhancing yield, quality, stress resistance and post-harvest characteristics, contributing to sustainable and efficient agricultural practices.

Key Words: *Plant growth regulators; Earliness; Sex modification; Delaying senescence; Vegetable production*

INTRODUCTION

Plant Growth Regulators (PGRs) or plant growth regulators, are substances that influence the growth and development of plants. These regulators may be artificial or natural and are frequently employed in agriculture and horticulture to manipulate various physiological processes in plants. Other hand phytohormones, also known as plant growth regulators, are chemical compounds that higher plants naturally create. They act in minute quantities to regulate growth or other physiological processes at a location apart from the source of synthesis. Based on their distinct functions, plant growth regulators can be divided into three main classes: ethylene, gibberellins, abscisic acid, cytokinins, auxins and gibberellins. Despite the fact that the term "plant hormones", another term for plant growth regulators is phytohormones [1]. The Greek word hormone is derived from the verb hormao (Upu w), which implies to stimulate or urge. An organic material known as a plant hormone is produced in one area of the plant and transported to another, where it triggers a physiological reaction at very low concentrations. It was referred to as phytohormone to differentiate it from animal hormone. Similarly, growth hormones are defined as chemicals that are produced in specific cells and then transmitted to other cells where they have a very tiny but significant effect on the process of development. But the word "hormone" is rather common and commonly used.

Phytohormones or plant hormones, are naturally occurring substances that are produced by plants and aid in the regulation of plant growth. Additionally, they are extremely versatile chemical controllers of plant growth. When these substances are generated, they are known as Plant Growth Regulators (PGRs). Rademacher [2] reported these findings. Internal plant hormones as well as artificial substances that have physiological properties akin to those of plant growth hormones or that can alter plant development in other ways are categorized as plant growth regulators. They are split up into two categories: Growth inhibitors (ethylene and abscisic acid) and growth promoters (auxins, gibberellins and cytokinin).

LITERATURE REVIEW

Use of plant growth regulators in solanaceous vegetable

Tomato: PGRs are advantageous for tomato growth characteristics and productivity. Different concentrations of GA_3 (20, 40, 60 and 80 ppm) and Naphthaleneacetic Acid (NAA) (25, 50, 75 and 100 ppm) were sprayed on the tomato plants. The maximum plant heights of 85.3 cm and 82.3 cm were noted when 100 ppm of NAA and 80 ppm of Gibberellic Acid (GA_3) were used. Using these concentrations boosted yield (483.6 q/ha and 472.2 q/ha), according to Prasad et al., [3]. In contrast to NAA at 50 ppm and GA_3 at 50 ppm, the application of Chlormequat chloride (CCC) at 500 ppm enhanced plant height, fruit number, fruit diameter and per plant seed yield after transplanting tomato seedlings over a 45-day period. Luitel et al., [4], who conducted 2,4-D experiments and discovered an increase in tomato yield in protected environments. They discovered that the highest fruit set (55.0 percent) was found with 5 ppm 2,4-D spraying on flowers, with 10 ppm following closely after. Nevertheless, the most fruits that a plant may produce (14.8) was produced with 10 ppm 2,4-D spray. Additionally, they discovered that 5 ppm was the second best fruit yield/plant (587.9 g), after 10 ppm.

Brinjal: During the blooming stage, the application of 2,4-D at a concentration of 2.0 ppm results in parthenocarpy, enhances fruit-set, speeds up fruit maturity and significantly boosts overall yield. When NAA at 40 ppm was combined with BARI Begun-5, the result was a high percentage of long-style flowering and an abundance of fruits and plants [5]. When compared to GA_3@100 ppm, 200 ppm and minimum reported in the control, Dhakar et al., [6] find that GA_3@150 ppm produced the largest plant height, per-plant number of leaves, leaf length, per-plant number of branches and stem diameter. The application of NAA at a concentration of 40 ppm produced the highest reported results for a range of growth and production metrics in brinjal plants, according to Singh et al., [7]. Plant height, the quantity of branches and leaves, average fruit weight, fruit girth, fruit length, fruit yield per plant, fruit yield per hectare and the number of fruits per plant are some of these measures. Included are days to 50% flowering as well. These findings imply that the best development and production in brinjal plants can be achieved by applying 40 ppm of NAA. The experimental treatment consisting of administering 80 ppm of NAA provided the highest fruit output and demonstrated superior plant height, fruit length, quantity of fruits per plant and time taken for initial flowering.

Chilli and capsicum: The highest seed output per plant, seed yield per fruit, average fresh weight of fruits per plant and average dry weight of fruits per plant were all achieved by spraying NAA@40 ppm as opposed to control [8]. The highest plant height, the number of branches, the days until the first flowering, the number of flowers per plant, the weight of the fruit, the number of fruits per plant, the number of seeds per fruit, the yield per plant and the yield of fruit per plot following the application of 60 ppm of NAA were all recorded for capsicum, according to Singh et al. [9].

According to Raj et al., [10], NAA at 75 ppm produced the highest yield (182.31 g) per plant and 6.37 t/hectare. However, plants that have been treated with GA_3 at concentrations of 20 and 60 ppm, respectively, generated the biggest plant height and the largest dry weight of 20 fruits. The plants treated with 2,4-D@7.5 ppm expanded in a north-south direction, with

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"EXPLORING THE IMPACT OF CRYPTOCURRENCIES ON MODERN FINANCE: A FOCUS ON BITCOIN, BLOCKCHAIN, AND INVESTMENT DYNAMICS"

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Abstract:
Digital transformation and the adoption of new technology are becoming increasingly essential for organizations, businesses, and individuals. Cryptocurrencies, such as Bitcoin, have been widely discussed in recent news. Bitcoin and blockchain technology have the potential to revolutionize our understanding of currency, transactions, and online identity. However, investing in cryptocurrency is highly speculative and involves trust issues.
Bitcoin, being a decentralized currency, is not influenced by any single entity. It is perceived more as a virtual investment than a tangible one, leading to comparisons with gambling. This paper aims to explore cryptocurrencies, their nature, and the role of blockchain technology in Bitcoin, along with associated risks. It also compares the risk levels of investing in cryptocurrencies to traditional stock trading.
Additionally, this paper presents a SWOT analysis of Bitcoin, highlighting recent events and trends that could impact its role in reshaping economic paradigms.
Keywords: Digital transformation, Bitcoin, Blockchain technology, Cryptocurrency investment, Risk assessment, Economic impact.

The Genesis of Bitcoin

In the midst of the financial crisis in late 2008, a pivotal post surfaced on an obscure internet forum titled "Bitcoin: A Peer-to-Peer Electronic Cash System." This groundbreaking piece was authored by an enigmatic figure using the pseudonym Satoshi Nakamoto, concealing their true identity.
Satoshi was disillusioned with the excessive power wielded by banks and governments for their own gain. He envisioned a new form of currency called Bitcoin that would challenge this status quo: a cryptocurrency not controlled by central banks or governments, allowing for free, borderless transactions worldwide, without reliance on any single entity.
Initially, Satoshi's radical ideas went largely unnoticed. However, as more people began buying and using Bitcoin, many saw it as the future of money, particularly as distrust in traditional banking institutions grew. Since its inception and launch in 2009, Bitcoin has evolved into a network of around 10,000 nodes or participants, utilizing the Proof of Work system to validate transactions and mine Bitcoin.
This democratic approach was prevalent until the rise of specialized mining computers, known as ASICs, which outpaced other less powerful machines, leading to the dominance of large mining pools and companies in the Bitcoin ecosystem. While individuals can still participate in Bitcoin, the setup costs are high, and the return on investment fluctuates with the volatile value of Bitcoin itself.
Today, major mining pools are controlled by large corporations, consolidating power once again. This development has somewhat deviated from Satoshi's original vision of a blockchain where power was evenly distributed among participants, now concentrated in the hands of a few mining conglomerates. Trading for profit is a significant driver of interest in these unregulated currencies, with speculators occasionally causing price surges.
"Many companies have created their own currency, also known as a token. This is often traded solely for the products or services they offer." These tokens can be likened to arcade tokens or casino chips. Cryptocurrencies operate using blockchain technology, a decentralized system spread across numerous computers that manages and records transactions.



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Revolutionizing Crop Improvement: A Review of Mutation Breeding Techniques and Their Applications

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Abstract

Genetic variation is the lifeblood of plant breeding. Induced mutation breeding, introduced in the 1920s, utilizes physical (radiation) or chemical mutagens to create heritable changes in plant DNA. This unlocks a vast pool of genetic diversity for developing improved crops.Mutation breeding has become a key player alongside recombinant and transgenic breeding methods. Physical mutagens like X-rays and chemical mutagens like EMS alter plant DNA, creating new variations. This technique has revolutionized crops like rice (over 800 improved varieties), wheat, barley, and peanuts, boosting yields, disease resistance, and other desirable traits.Recent advancements are even more promising. Combining traditional mutation techniques with molecular markers and high-throughput screening allows for rapid identification of beneficial mutations. This "molecular mutation breeding" holds immense potential for creating climate-resilient crops with enhanced nutrition, tackling malnutrition.The future of mutation breeding lies in continuous improvement and integration with cutting-edge technologies. By harnessing mutations, researchers can tailor crops to environmental stressors, reduce reliance on pesticides, and ensure food security for a growing population. Optimizing protocols and ensuring equitable access to this technology are crucial for realizing its full potential in sustainable agriculture.Induced mutation breeding stands as a powerful tool for developing the resilient and nutritious crops we need for the 21st century. Through ongoing advancements and collaboration, it holds the key to a more sustainable and food-secure future.

Key words: Mutation breeding, Genetic variability, Mutagenesis, Crop improvement, Food security

Introduction

Genetic variation is the cornerstone of evolution and practical breeding, essential for the development of new plant varieties. Natural variations, arising from genotypes recombining within populations and interacting with environmental factors, are crucial for adaptation and survival. Green plants play a vital role in human existence, serving as a source of food, clothing, and energy resources since ancient times. Early human societies, such as prehistoric hunter-gatherers, relied on their hunting skills and the abundant natural vegetation to procure non-poisonous and nutritious food items like fruits, tubers, and seeds. However, as human populations grew, the demand for larger and safer food supplies necessitated the development of large-scale production systems through plant domestication.Plant breeding, the process of developing new plant varieties for cultivation and human use, has evolved over millennia. Initially, simple selection of desirable offspring, exploiting spontaneous mutations, was the primary breeding method. However, the field of plant breeding advanced significantly with the discovery of Mendel's laws of heredity in the nineteenth century, which laid the foundation for modern genetics. Subsequent developments, such as hybridization, aimed to combine desirable genes from different varieties to produce superior progeny. Crossbreeding, based on trait selection following the crossing of different genotypes, became a common practice, leading to the development of improved plant varieties [1] [5] [24].



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TRANSFORMATIONAL LEADERSHIP IN HIGHER EDUCATION: A STEP TOWARDS INNOVATION AND POSITIVE CHANGE

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ABSTRACT

The induction of leadership within the educational grounds proves to be highly important for the establishment of a stronghold over the working performances. Several ranges of leadership and managerial styles can be induced within the working environment, for bringing about a positive change within the educational sector, such as democratic and transformational leadership. The study has laid an examination of the different attributes of transformational leadership for the induction of positive change and innovation inculcation within the higher education sector. The different characteristics of the respective style of leadership, in addition to the issues for its inculcation, and the strategies for a more potent form of leadership, have been assessed in the study. The positive changes brought about by the impregnation of transformational leadership, to meet the needs and the demands of the educational sector have been laid down in the study.

Keywords: Transformational Leadership, Innovation, Change, Management, Educational Institutes, Higher Education

1. INTRODUCTION

The initiation of change management within the corporate sector needs to be configured effectively to halt the disruption of work. In addition to such, the inculcation of innovation and creativity is enabled by a positive approach and allows the propelling of the changes in a forward direction. With the aid of transformational leadership, educational institutes have the benefit of integrating positive change within their culture. The presence of such a style of leadership has been seen to encourage the students to gain a greater level of confidence to meet their desired aim and allow the teachers and the faculty to improve their approaches towards the pupils. Cohesively, the overall betterment of the higher educational sector can be noted with the aid of the transformational style of leadership.

2. AIM

The study aims to lay an assessment of the integration of transformational leadership in the grounds of higher education, to bring about a positive and innovative change in culture.

3. OBJECTIVES

The research objectives developed for the study are as follows:

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Effect of organic and inorganic nutrients with combination of biofertilizers on the growth and yield performance of wheat

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Abstract

Wheat, being a staple crop globally, faces increasing challenges due to population growth, climate change, and soil degradation. To sustainably boost wheat production, innovative agricultural practices are essential. The application of Different treatment levels recorded significant variation on growth parameters during the experimentation. The growth parameters of wheat *viz*., plant height, produced by (T_{12}) 100% RDF + 20 t FYM + *Azotobacter* + PSB + *Trichoderma* proved significant superiority over control at all dates of observation. Application of (T_{12}) 100% RDF + 20 t FYM + *Azotobacter* + PSB + *Trichoderma* significantly produced the maximum value of the yield attributing characters like number of effective tillers, spike length, grains spike^{-1} and 100-grain weight. Similarly, T_{11} significantly increased grain yield and straw yield as compared to other treatment. Among the different sources of nitrogen, application for (T_{12}) 100% RDF + 20 t FYM + *Azotobacter* + PSB + *Trichoderma* recorded higher grain yield followed by T_{11} , 100% RDF + Rhizobium + PSM and T_{10} ,50% RDF + 10 t FYM ha^{-1} + Rhizobium + PSM Control, T_9 , 50% RDF + 10 t FYM ha^{-1}, T_8 ,50% RDF + Rhizobium + PSM , T_7 ,100% RDF (20-40-0 kg NPK ha^{-1}) PSB + *Trichoderma* , T_6 ,50% RDF (*Azotobacter* + *Trichoderma*), T_5 ,50% P_2O_5 (20 kg P_2O_5 ha^{-1}) + *Rhizobium*, T_4 ,50% N (10 kg N ha^{-1}) + PSM, T_3 ,*Rhizobium* + PSM T_2 ,FYM 20 t ha^{-1}, and control. Significant effects on both growth and yield parameters were observed as a result of various combinations of organic and inorganic fertilizers. The most favorable outcomes were observed in treatment (T12) utilizing 100% recommended dose of fertilizer (RDF) along with 20 tons of farmyard manure (FYM), supplemented with Azotobacter, PSB, and Trichoderma. This treatment exhibited superior results compared to others, while the control group showed the least favorable outcomes.

Keyword: Wheat, organic and inorganic nutrients, biofertilizer, growth, yields

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important staple food crop of the world and emerged as the backbone of India's food security **(Prasad, 2006).** Wheat is second most important crop next to rice and it contributes nearly one third of total food grain production. It is good supplement for nutritional requirement of human body. Wheat straw is also used as dry fodder for livestock. It contains 10-12 percent protein and 65-70 percent carbohydrates **(Sharma and Jain, 2014)**. Wheat cultivation plays a vital role in global food security. However, conventional farming practices often lead to soil degradation, nutrient depletion, and environmental pollution. Addressing these challenges requires a shift towards sustainable agricultural approaches. Integrating organic and inorganic nutrients with biofertilizers presents a promising solution to enhance wheat productivity while minimizing adverse environmental impacts. Combining organic amendments such as compost, manure, and crop residues with inorganic fertilizers offers several advantages:

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Examination and Characterization of Pellet of Wild and Domestic Animals for Forensic Consideration

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ABSTRACT

The purpose of this study is to use pellets to collect data on a variety of wild and domestic animals. Find the data shows that people can use pellets to identify different types of wild and domestic animals. In this study, 13 pellets were taken from wild animals and 10 pellets were taken from domestic animal such as horses, sheep, goats, dogs, rabbits, cats, buffalo, donkeys, camels, tigers, lions, leopards, elephants, pigs, Gaurs. After thoroughly observed the pellets of various wild and domestic animals, we took photographs of different types of pellets with different colors, shapes, patterns, and dimensions. The study found that all domestic and wild animal pellets have different colors, shapes, patterns, and dimensions. After thorough examination and measurement of the pellets, it was concluded that the largest pellets in wild animals were from elephants, and in domestic animals, they were from buffaloes.

Key word: Pellets, Wild animal, Domestic animal, Colors, Shapes, Pattern and Dimension.

Introduction

A critical step in a wildlife crime investigation is identifying the species included in the evidence. Some species have no legal status, and others are highly protected, with severe penalties for killing and commercial dealing. Therefore, determining whether a wildlife crime has been committed requires establishing a taxonomic identity (Pepper, 2021). Morphological analysis involves trained and proficiency-tested professionals identifying species based on physical characteristics present in evidence. The pattern of plumage in birds, the dentition of mammals, or the number of scales in reptiles. Evidence items are compared to verified reference specimens and/or authoritative data sources, and taxonomically informative features are documented (Lyman , 2019).

Pellets are animal waste (feces) and play a very important role in distinguishing between wild and domestic species. All animals have different pellet shapes, patterns, and dimensions. There are different types of pellets: separate hard lumps, lumps and sausage shapes, sausage shapes with cracks on the surface, smooth and soft, snake-shaped, soft lumps with sharp edges, jagged edges and thick consistency, liquid consistency without solid parts (Lewis and Heaton, 1997).

This is also a unique personality trait of different animals and allows us to identify animal species in the forest. After seeing a fresh or dry pellet, you can also identify whether the animal is from the area or nearby. Therefore, consideration should be given to using less nutrient-rich elements to maximize en-

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UNVEILING THE SYNERGY: COMPUTER SCIENCE AND PSYCHOLOGY

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Abstract:
It is commonly considered the confluence of disciplines such as computer science, behavioral sciences, design, media studies, and various other fields. As technological trends keep advancing, these developments in computer science are somewhat 'taking over' the work of psychologists. When it comes to computer science, key topics like encryption become part of the conversation here. Influence of Computer Science on Psychology Artificial intelligence and machine learning are fast growing terms that you should be familiar with. Computer Science and Psychology are two disciplines which have evolved over the years. It involves replicating human cognitive abilities, like learning and problem-solving, within a computerized framework. Overview of Computer Science The main aim of Computer Science is to provide intellectual tools which will enable students to operate effectively in and contribute meaningfully to fields typically different from Computer Science itself. They directly interface computer science with the human mind, improving understanding of mental processes and diagnosing mental illnesses. The field of Human-Computer Interaction encompasses the examination, strategizing, and development of the exchange between individuals (users) and computers. Robotics, digital forensics, software testing and drone technology are all specialties to consider that come with a background degree in computer science. The paper focuses on how computer science and psychology, privacy and data security are of great concern for the two fields.

Keyword: Robotics, digital forensics, software testing, drone technology, human-computer interaction

1. Introduction

Computer science is the study of how technology are designed and how we can use computers to improve our work. Computer Science provides a foundation for virtually any career in technology. Robotics, digital forensics, software testing and drone technology are all specialties to consider that come with a background degree in computer science. Psychology is the scientific study of the mind and behavior, according to the American Psychological Association. Psychology is a multifaceted discipline and includes many sub-fields of study such areas as human development, sports, health, clinical, social behaviour and cognitive processes. Computer Science and Psychology are two disciplines which have evolved over the years. In the first place, they have diversified in ways that have made them lose their initial fundamental relationship and association. Secondly, their relationship has been redefined and renewed in greater depth and understanding than ever thought before.

1.1. Overview of Computer Science

The main aim of Computer Science is to provide intellectual tools which will enable students to operate effectively in and contribute meaningfully to fields typically different from Computer Science itself. With the intuitive understanding of algorithms it provides programmers, it is why Computer Science is a requisite to students having a background in programming; and offers them the pure intellectual challenge as the students will master the depth and elegance of the intricate hierarchy of languages, machines and operating systems.

This branch of science is the scientific and practical approach to computation and its applications. It is the systematic study of the feasibility, structure, expression, and mechanization of the methodical processes (or algorithms) that underlie the acquisition, representation, processing, storage, communication of, and access to information, whether such information is encoded in bits and bytes in a computer memory or transcribed in genes and protein structures in a human cell. Its core areas

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"ADVANCEMENT IN HEALTH DIAGNOSTIC SYSTEMS: A COMPREHENSIVE REVIEW OF AI AND ML APPLICATIONS"

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Abstract:
The rapid integration of Artificial Intelligence (AI) and Machine Learning (ML) into health diagnostic systems has revolutionized the field, offering unprecedented advancements and transformative possibilities. This comprehensive review aims to provide an in-depth exploration of the applications of AI and ML in health diagnostics, shedding light on their evolution, current state, and future potential. Beginning with a historical perspective on health diagnostics, the paper navigates through the milestones of AI and ML in healthcare, emphasizing their pivotal role in addressing limitations of traditional methods.

Theoretical foundations are established, elucidating key concepts such as machine learning algorithms and neural networks. The integration of AI and ML into health diagnostic systems is systematically explored, covering data preprocessing, feature extraction, training, validation processes, and real-time applications. The paper meticulously examines the applications of AI and ML across various domains of health diagnostics, including imaging, clinical, and laboratory diagnostics, showcasing their potential to enhance accuracy, automate processes, and facilitate personalized medicine.

While highlighting the successes through case studies, the review does not shy away from addressing challenges and ethical considerations. Discussions encompass data privacy, algorithmic bias, interpretability, and compliance with regulatory standards. Drawing from real-world implementations, the paper seeks to offer insights into overcoming challenges and navigating ethical dilemmas in the pursuit of enhanced health diagnostics.

The review concludes with a forward-looking perspective, outlining emerging trends, potential breakthroughs, and areas for future research. It underscores the need for collaborative efforts among researchers, practitioners, and policymakers to harness the full potential of AI and ML in health diagnostics. This comprehensive exploration serves as a valuable resource for those seeking a deeper understanding of the current landscape and future trajectories of AI and ML applications in health diagnostics.

Keywords:
Health diagnostics, Laboratory diagnostics, Imaging diagnostics, clinical diagnostics, machine learning in health diagnosis, AI in health diagnosis.

I. Introduction:

Health diagnostics have traditionally relied on manual assessments, subjective interpretations, and time-consuming processes, often leading to delays, inaccuracies, and limited personalization. In recent years, however, the integration of Artificial Intelligence (AI) and Machine Learning (ML) into health diagnostic systems has ushered in a new era of innovation, fundamentally transforming the landscape of medical diagnostics. This revolutionary amalgamation of advanced technologies offers unprecedented opportunities to enhance accuracy, efficiency, and patient outcomes.

As we establish the theoretical foundations of AI and ML in the context of health diagnostics, key concepts such as machine learning algorithms and neural networks will be elucidated. The systematic exploration of the integration process will cover crucial aspects, including data preprocessing, feature extraction, training, validation processes, and real-time applications. Through this exploration, we aim to offer a clear understanding of the intricacies involved in implementing AI and ML in health diagnostic systems.

While highlighting the successes achieved through real-world case studies, we will also address the challenges and ethical considerations inherent in the use of AI and ML in health diagnostics. Discussions will encompass crucial topics such as data privacy, algorithmic bias, interpretability, and

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REVIEW ARTICLE

Organic farming technologies for horticultural crops

B D Sharma, R. Bhargava, Bankey Lal*, Ravi Kumar

Sharma BD, Bhargava R, Lal B, et al. Organic farming technologies for horticultural crops. AGBIR.2024;40(1):880-883.

In India, about 62 per cent of cropped area is rain fed, where there is little or no use of fertilizers and other agro-chemical due to poor resources with small holding farmers. Thus promotion of organic farming in India is advocated initially in the arid and semi-arid areas of the country in some selected crops. In horticulture, it is easier to manage fruit crops organically than vegetable and flower crops due to perennial growth habit. The arid horticultural crops which are considered high valued health food and being easily grown organically for years are the best suited for organic cultivation e.g., custard apple, fig, jamun, tamarind, pomegranate, aonla, sapota, guava, citrus, ber, khejri, moringa etc. Vegetables are rich and cheap source of vitamins and mineral which act as a protective food in daily diet and they are also consumed raw as a salad and are major source of fibre in diet, however, vegetable crops are vulnerable to disease and pests, therefore they need chemical sprays to protect from them. Similarly, for getting optimum yield, they need chemical fertilizers. Thus in commercial vegetable production with the increase in chemical inputs, the risk of degradation of environment and residue problems has increased. Therefore, it is needed to grow vegetables organically. The concept of organic farming is to demonstrate the effectiveness of low cost agriculture, thereby increasing the net income from successive crops and not only texture and structure of soil but the quality of agricultural output. The major principles of organic farming are to use the organic manures to maintain soil fertility of soil, use of bio-fertilizers, use of bio-control agents for controlling pests and diseases, use of resistant varieties, better soil management practices like solarization, mulching, cover cropping, intercropping, crop rotations and use of pheromones. Therefore, efforts are made in this communication to focus on the research work done on these aspects in fruit and vegetable crops in India. For getting success in the organic farming, let us strive to pool all our indigenous knowledge on safe horticulture practices and evolve new organic farming technologies for which concentrated efforts are needed from the scientists, planners, personnel's involved in the development of horticulture, extension agencies and the farmers themselves.

Key Words: *Organic farming; Horticulture; Vegetable production; Fruit production*

INTRODUCTION

Four decades of "Green Revolution" based technologies of high yielding varieties, chemical fertilizers, pesticides, fungicides and herbicides and irrigation enabled rise in agricultural production in India and led to self-sufficiency. However, the negative consequences of high input agriculture, which envisage large chemical inputs and few carbon additions, on long term profitability and resource sustenance, are now beginning to appear. This include: Wide spread soil erosion, salinization, decline in soil quality due to reduction in soil organic matter content, poor soil fertility, poor surface water quality, reduced water infiltration rates and unfavorable soil tilth, pesticide pollution, desertification, loss of biodiversity and adverse effects on human health. Hence presently there is a growing interest to practice alternative agricultural system that are less exploitative, less dependent on non-renewable fossil fuels like fertilizers pesticides, etc., which can conserve the precious soil and water resource and protect the environment and human health. Organic farming is therefore an alternate farming strategy that focuses on soil health, environmental protection and human health by largely excluding the use of synthetic chemical and with minimum use of off-farm inputs.

LITERATURE REVIEW

In India, about 62 per cent of cropped area is rain fed, where there is little or no use of fertilizers and other agro-chemical due to poor resources with small holding farmers. Thus promotion of organic farming in India is advocated initially in the arid and semi-arid areas of the country in some selected crops like ber, pomegranate, anola, custard apple, tamarind, fig and other minor fruit of economically importance. Rather than promoting organic farming en masse, it would be appropriate carefully delineate areas or crop where fertilizer use is nil or nominal or demarcate export oriented crops that can give reasonable yield of high quality produce without the use of chemicals. It is worthy to mention that arid fruit and vegetable crops hold great promise in this regard.

From the limited research carried out, there is a definite promise for organic farming of fruit and vegetable crops in arid region. In horticulture, it is easier to manage fruit crops organically than vegetable and flower crops due to perennial growth habit. The arid fruit crops which are considered high valued health food and being easily grown organically for years are the best suited for organic cultivation e.g. custard apple, fig, jamun, tamarind, pomegranate, aonla, sapota, guava, citrus and ber. Therefore, in future more efforts are needed to standardize organic techniques in these crops.

Vegetables are rich and cheap source of vitamins and mineral which act as a protective food in daily diet. They are also consumed raw as a salad and are major source of fibre in diet. However, vegetable crops are vulnerable to disease and pests, therefore they need chemical sprays to protect from them. Similarly, for getting optimum yield, they need chemical fertilizers. Thus in commercial vegetable production with the increase in chemical inputs, the risk of degradation of environment and residue problems has increased. Therefore, there is need to grow vegetables organically today.

During the last two decades, organic agriculture has emerged as a very dynamic alternative farming system in several countries of the world. This has been necessitated as a result of the adverse effect of inorganic agriculture making excessive use of inorganic fertilizers, pesticides and chemicals necessary to achieve high yields of various crops. Green revolution started on soil rich in organic carbon and the response to applied fertilizers was spectacular. With passes of time, green revolution-showing symptoms of degeneration of soil fertility and deterioration in environmental quality. Excessive use of plant protection chemicals and imbalanced use of fertilizer has further resulted in escalation of the above problems including exorbitant cost on cultivation due to low nutrient efficiency. Such an approach has resulted in change in soil structure, imbalances in soil microorganism and organic matter increased salinity, sodicity, affect water holding capacity of soil and brought in health and environmental problems related with pesticides residue.

Concept of organic farming

There is no single definition for organic farming as the term refers to a movement rather than to a single policy. As per USDA, 1980 report "organic farming can be defined as: Production systems which avoid or largely exclude the use of synthetically compound fertilizers, pesticides, growth regulators and livestock feed additives". To the maximum extents feasible, organic system rely upon crop rotations, crop residues, animal manures, legume

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REVIEW ARTICLE

Precision horticulture a modern approach to smart farming: A review

Surabhi Sharma[1], Bankey Lal[2*], Arun Kumar Verma[3], Vipul Pratap Singh[3]

Sharma S, Lal B, Verma AK, et al. Precision horticulture a modern approach to smart farming: A review. AGBIR.2024;40(2):945-948.

A number of important elements, including social justice, economic sustainability and environmental health, are integrated into precision farming. In order to achieve this, it emphasizes the precise management of crops through the use of state-of-the-art technologies such as Remote Sensing (RS), Geographic Information Systems (GIS) and Global Positioning System (GPS) in conjunction with ground equipment like yield monitors, Variable Rate Applicators (VRA) and computer systems with the necessary software. Precision agriculture is essentially a systematic strategy that aims to restructure the entire agricultural system in order to adopt a farming model that is high-efficiency, low-input and sustainable. Prioritizing technology-driven horticulture precision farming as a potential solution is becoming more and more necessary in light of the escalating challenges presented by an expanding global population and unexpected environmental fluctuations. This approach holds great potential for addressing these pressing issues and ensuring the future sustainability of agriculture.

Key Words: *Precision farming; Sustainability; Global positioning system; Remote sensing*

INTRODUCTION

As the global population continues to grow, urbanization accelerates and natural resources weaker, farmers must undergo a fundamental shift in their mindset. This shift involves transitioning from an exclusive focus on production to a broader emphasis on productivity and profitability. The contemporary challenges faced in agriculture primarily revolve around diminishing land availability and the depletion of critical resources, particularly water. To address these challenges, it is imperative to promote farmer-friendly, location-specific production management technologies in a concerted effort. This approach seeks to propel vertical growth in horticultural production while ensuring the quality of produce and enhancing financial returns per unit of land area. Central to this endeavor, precision farming plays a pivotal role by facilitating the efficient utilization of resources over specific periods and land areas to attain the targeted production of horticultural crops.

Professor Pierre C. Robert, often regarded as the pioneer of precision farming, provided a defining perspective on this approach. He emphasized that precision agriculture represents not merely the incorporation of new technologies but rather an information-driven revolution made possible by these innovations, leading to a more refined and precise farm management system. Fundamentally, it involves the application of the right treatments in the right quantities, at the right time and location within a field [1]. Precision farming harnesses modern technologies, including remote sensing. However, in countries like India, where the majority of farmers have small land holdings averaging between 1 to 2 acres, using aerial remote sensing to access detailed information about natural resources, especially soil data, has proven to be a challenge. Advancements in remote sensing particularly increased spatial resolution have enabled the application of precision farming methods even on smaller land areas [2].

This scientific approach leverages Information Technology (IT) and satellite-based technologies to identify, analyze and manage the spatial and temporal variations in agronomic parameters such as soil quality, diseases, nutrients and water within fields [3]. It achieves this by precisely applying the necessary inputs to optimize profitability and sustainability while minimizing environmental impact [4]. Current research, such as the study on "Integrating farmer knowledge, precision agriculture tools and crop simulation modeling to evaluate management options for underperforming areas in crop fields", holds significant promise, particularly for a country like India [5]. In India, there are relatively developed regions that can serve as incubators for novel ideas and sophisticated technologies tailored to domestic conditions.

LITERATURE REVIEW

Techniques for precision farming

Precision farming is the management and understanding of variability over time and space. This system is based on use of information generated through survey to manage this variability by matching inputs to conditions within field using site-specific inputs like such as computer system, GPS system, GIS system, RS system, VRA system, yield mapping technology, soil and crop sensing technology, DRIS and SSNM for precision farming in horticulture and waste management in context to precision horticulture in specific site.

Computer system

Computers have help to define precision farming in terms of management strategy that uses information technologies for decision making [6]. Precision farming requires the acquisition, management, analysis and output of large amount of spatial and temporal data. Computer software in precision agriculture has become better with time for precision farming, the knowledge needed is that for managing variability on the farm, knowledge that is requisite for decisions making. Therefore, in this system, computers and related software have become capital inputs [7].

Global positioning system

Many satellite constellations assist the positioning system in its operation. Precision agriculture is now a reality because to advancements in positioning systems. These developments represent the primary technological milestone. For the field use of variable rate technology, GPS offers a precise locating system [8]. It allows for the precise positioning of farm equipment to within inches, controls the administration of inputs by machinery and prescribes fertilizer and pesticides based on the characteristics of the soil. The US Department of Defense (DOD) created the Global Positioning System (GPS). The Russian Global Navigation Satellite System (GLONASS) location system is comparable [9]. There is debate over the European Global Navigation Satellite System (GNSS) or "Galileo" [10], hence, a definition study supported by the European Union (EU) and the European space agency is underway [11]. For every task in GPS, all location data should be distributed and stored from a single system located at a central vehicle (such the tractor) [4]. According to Spilker [12], the primary benefit of a central system is that position data are computed based on the application and sent straight to the location where they will be utilized. Kinematic GPS (KGPS), a more precise positioning technology with centimetric accuracy, is not utilized in precision agriculture because of cycle ambiguity issues [13].

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RNB Global University Registrar Bikaner

REVIEW ARTICLE

Lettuce: A dive into its nutritional value and economic significance

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Lal B, Bhandari S, Upadhyay A, et al. Lettuce: A dive into its nutritional value and economic significance. AGBIR.2024;40(2):954-956.

Lettuce is a rich source of nutraceutical and pharmaceutical, antioxidants phyto chemicals compounds which are rich in anticarcinogenic properties. It is one of the most well-known green vegetables in the world, lettuce has several purposes outside of food. Customers can select from a variety of varieties in the lettuce category. Furthermore, lettuce is a great source of health-promoting bioactive substances like chlorophyll, carotenoids and polyphenols. In addition, there are differences in the nutrient makeup and antioxidant components of different types of lettuce, particularly between green and red variants. The nutritional value of lettuce is contingent upon its composition, namely its antioxidant content, which can serve as a vitamin. The health advantages are dependent on how they enter the bloodstream and function biochemically. In the digestive tract, certain ingredients may be changed or released from the food matrix.

Key Words: *Lettuce; Economic importance; Antioxidant; Flavonoids; Phenolic acids*

INTRODUCTION

Lettuce (Lactuca sativa L.) has chromosome number 2n=18, which places it in the Compositae (Asteraceae) family. Originating from the Mediterranean region, this crop is widely grown for salads worldwide [1]. The Latin word "Lactuca" for milk is the source of lettuce's name, as chopped leaves release a milk-like substance known as sap. Also referred to as "The King of salad crops" it is frequently found in fast food. It grows a short stem at the beginning of the season and the cluster of leaves varies greatly among variations in terms of shape, personality and color. A temperate region's annual crop for the cool season is lettuce. A popular salad crop in North America, Australia and the majority of Europe and South America is lettuce. Consumption and production of lettuce are highest in the USA. China holds the top spot in the global lettuce production rankings, while India grows lettuce in kitchen gardens to supply continental hotels [2].

Since lettuce is a crop native to temperate regions, it requires chilly temperatures to germinate. It may be cultivated satisfactorily at mean temperatures between 130°C and 16°C. When the soil temperature rises above 22°C, seeds do not germinate as intended. The ideal range of temperatures for seed germination is between 18°C and 21°C. The finest soil types for growing lettuce are sandy loam or silt loam; the ideal pH range for commercial production of lettuce is 5.8 to 6.6 [3].

A good source of vitamins A, C and B complex, as well as pyridoxine, riboflavin and thiamine is lettuce. It also offers some protein, carbs, dietary fiber and a negligible quantity of fat. Additionally, lettuce offers elements primarily present in the leaf, such as calcium, iron and copper [4]. Most people eat lettuce raw in salads and sandwiches. In Chinese cooking, the leaves are occasionally cooked as an herb [3].

Typically, it is used shredded in a salad with other salad vegetables including tomato, cucumber, onion and carrot. Chop the fragile leaves and heads and eat them as salad. Moisture (93.4 g), protein 2.1 g, fat 0.3 g, minerals 1.2 g, fiber 0.5 g, carbohydrates 2.5 g, calcium 50 mg, phosphorus 28 mg, iron 2.4 mg, vitamin A 1650 I.U., thiamine 0.09 mg, niacin 0.50 mg, riboflavin 0.13 mg, vitamin C 10 mg and energy 2.1 kcal are all present in one hundred grams of edible lettuce [5].

One of the most popular green vegetables consumed worldwide, lettuce has a number of therapeutic benefits in addition to its economic significance. It is a grade commercially significant salad crop that is available year-round on the market. Lettuce contains various health-promoting and therapeutic components, including flavonoids, phenolic acids and antioxidants [6]. The prevention and treatment of diseases like cancer and heart problems have been studied while using these helpful components for health. Lettuce has anti-inflammatory characteristics that aid in managing inflammation. It is advantageous in lowering the risk of diabetes and enhances bone health and bodily metabolism. Additionally, the antioxidant activity of flavonoids can lower the risk of cardiovascular disease and cancer. Lettuce is a rich source of nutraceutical and pharmaceutical, antioxidants phytochemicals compounds which are rich in anticarcinogenic properties [7]. Due to the bioactive chemicals found in vegetables, eating lettuce has health benefits for people [8]. Consuming vegetables has been linked in certain epidemiological studies to a decreased risk of chronic illnesses such cancer and cardiovascular disease [9]. One of the main natural sources of phytochemicals is lettuce [10]. Bioactive nutritional components, such as glycosylated flavonoids, phenolic acids, carotenoids, vitamin B groups, ascorbic acid, tocopherols and sesquiterpene lactones are essential. Furthermore, the results showed that the plasma redox status of healthy individuals was not changed by consuming lettuce stored in packaging with a modified environment [11]. *Lactuca sativa* has also been shown by various researchers to be effective in treating oxidative damage, cancer, diabetes, Alzheimer's disease and other illnesses [12,13].

LITERATURE REVIEW

Natural antioxidants that have been isolated and identified from plant sources include: Organic fertilizers can be used to improve the quality of leafy vegetables and human health by reducing the amount of toxic substances like nitrates produced by conventional fertilizers in vegetables like lettuce [14]. For agricultural use and ecological balance, organic fertilizers replace inorganic fertilizers. Plant leftovers, livestock manure, farm yard manure and industrial wastes are the main sources of organic fertilizers. Organic fertilizers give lettuce the nutrients it needs to grow, yield more, and improve its quality [15].

In addition to being a protective agricultural input that improves the physical, chemical and biological properties of soil and increases soil fertility, porosity and water holding capacity, vermicompost is a very nutrient-dense organic fertilizer that is more potent than traditional compost at promoting growth. The best way to improve the vegetative development, quality and yield performance of lettuce crops is to use vermicompost. Higher levels of readily available nutrients, such as nitrate and ammonical nitrogen, phosphorus, potassium, calcium and magnesium that are produced from wastes, are found in vermicompost.

Sustainable agriculture and ecologically friendly systems use bio-fertilizers and bio-pesticides, respectively. In addition to chemical fertilizer, biofertilizers offer an inexpensive, sustainable source of plant nutrition.

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Playing on The Grass

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Amidst the rural landscape, where the horizon kissed the earth in a seamless blend of hues, two trees stood sentinel by the roadside, witnesses to the passage of time and the stories of men. Their branches reached toward the heavens, grasping at the fleeting whispers of the wind, while their roots delved deep into the earth's embrace, anchoring them steadfastly to the soil. One evening, bathed in the golden glow of a setting sun, a father brought his son to the foot of one of these trees, eager to impart a timeless lesson. With patient hands and steady guidance, he taught the boy the art of climbing, instilling within him the courage to ascend to greater heights. Beside this tree, its companion stood silent witness to another scene. A child approached, beseeching his father to learn the same skill. The father says, "If you climb there is a high chance that you will fall and break your bones. Better to play on the grass." The father cautioned against the perils of such endeavors, urging his son to remain grounded upon the safety of the earth below. Paralyzed by uncertainty and the weight of apprehension, the child withdrew, became conscious, stepped back, and couldn't decide what to do. He lost confidence, and couldn't trust his instincts which were high earlier that he could do it, his youthful spirit dampened by the specter of fear.

With each passing day, the seeds of doubt took root within the boy's heart, choking the once-vibrant aspirations that had dared to bloom. He never climbed on the tree. He didn't even dare to learn it. As he matured his zest for life waned, overshadowed by the looming shadow of hesitation that clouded his every thought. Instead of creation, innovation and courage it was fear he sensed first.

Months later, fate reunited the boy with the trees that had borne witness to his thwarted ambitions. He gazed at the tree he yearned to climb, feeling a sudden pang of longing. It stood barren, devoid of leaves. On the other side, it was the very same tree where he had once observed boys learning to climb. That tree flourishing under the joyful laughter and exuberance of a group of children who fearlessly embraced the thrill of climbing, oblivious to the specter of danger. Intrigued, he approached them, He asked the boys, "Aren't you all afraid of breaking your bones"? Boys look at each other, laugh and said, "We have never even thought about it. This is our way of playing in nature. Our fathers taught us to climb on the trees. We never

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Supply Chain Dynamics with Sensor Integration for Consumer Electronics in Retail and E-commerce

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Abstract— **In this innovative study, a cutting-edge dual-channel closed-loop supply chain model with sensor data integration for third-party recycling has been effectively developed. Our innovative study provides unmatched insights into the world of consumer electronics by examining the effects of fund management regulations and retail e-commerce participation on three different choice scenarios. The compelling results show that retail e-commerce, the revolutionary force in the retail industry, has a tangible impact on the pricing and profits of traditional brick-and-mortar stores. In response to this trend, the wholesale pricing strategies of consumer electronics manufacturers have been adapted to maximize profitability within the retail e-commerce landscape. Fascinatingly, the impact of retail e-commerce involvement remains impervious to the recycling decisions and optimal profits of third-party recyclers. In consumer electronics, fund-handling policies are crucial in boosting the number of product recoveries and driving up prices for businesses in the forward supply chain. Although manufacturers' market share is affected by retail e-commerce, overall product demand is unaffected. On the other hand, putting fund-handling policies into place indicates a decline in overall market demand. This innovative study uses sensor integration to unlock the complex dynamics of the interesting field of digital supply chain management.**

Index Terms— **Supply chain dynamics, Retail E-commerce, consumer surplus, Sensor integration, Market demand.**

I. INTRODUCTION

THE concept of integrating sensors into consumer electronics has recently emerged as a feasible solution to address resource depletion and environmental degradation. By using sensor integration for product recovery and remanufacturing, this technique helps the economy. Recognizing this approach's potential, numerous consumer electronics businesses have successfully used it. The widespread adoption of sensor integration in consumer electronics in recent years has resulted in notable progress in closed-loop supply chains. To achieve the circular usage of resources, Apple implemented a recycling program for consumer electronics. To achieve the cyclical consumption of resources, Apple launched a recycling program for consumer gadgets. Through the recycling and reuse of toner cartridges, Xerox was able to reduceproduction costs by integratingsensor technologies. By integratingsensor technology, Xerox was able to achieve a reductionin production costs through the reuseand recycling of toner cartridges [1].

The closed-loop supply chain is a key strategy for sustainable development that centers on the recovery of consumer electronics. Third-party recovery is a common recycling model in the supply chain. Third-party recovery companies have unique advantages. Greenpeace provides customers with convenient recycling services through its "Recovery Brother" app. They also develop professionaldismantlingand processing techniques to improve resource reusability [2]. It has been possible to successfully design a cutting-edge dual-channel closed-loop supply chain model that incorporates sensor data for third-party recycling. The effects of fund management regulations and retail e-commerce involvement on three different choice situations. To address the current recycling market situation, the "Regulations on the Management of Recycling and Treatment of Waste Electrical and Electronic Products" (known as the Treatment Fund Policy) aim to support the development of third-party recovery companies [3, 4].

This paper builds on previous research exploring the impact of the Treatment Fund Policy on closed-loop supply chains in the context of consumer electronics. Authors analyzed various aspects, from the effect on supply chain decisions and recovery quality to manufacturers' channel selection and the impact of recovery policies on backward-capacity manufacturers. However, these studies often overlooked the forward supply chain dynamics [5], particularly sales channels, in consumer electronics, despite the importance of integrating forward and reverse logistics in real-life closed-loop supply chains [6]. The shift towards direct online sales, as adopted by companies like Estée Lauder and Nike, in the consumer electronics industry highlights this aspect's significance. Consumer electronics, even though real-world closed-loop supply chains require the integration of forward and reverse logistics. Understudied are

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Phytochemical and Biological Properties of Domesticated Capsicum Species: A Review

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Review Article

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ABSTRACT

America is the original home of the *Capsicum genus* (Solanaceae). It is now a significant agricultural crop grown all over the world, not only for its commercial significance but also for the fruits' high nutritional worth. Capsicum and its various variants have many beneficial qualities that set them apart from other vegetables. They are also used as a spice in many foods due to its potent, pungent flavour, which is created during the plant's secondary metabolism. Due to the

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Effects of Organic Manures and Inorganic Fertilizer on Growth and Yield Performance of Radish (*Raphanus sativus* L.) c.v. Japanese White

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Original Research Article

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ABSTRACT

A Field experiment was carried out during *Kharif* season of 2018 at the research farm in Udai Pratap (Autonomous) College; Varanasi (U.P.), India. The site was adjoining to the Department of Horticulture of the college. The experiment consisted of Six treatments comprising of combinations of recommended doses of organic and inorganic manures (FYM, Vermicompost and poultry manures). The experiment was laid out in a Randomized Complete Block Design (RBD) with six

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Phytochemical and therapeutic potential of broccoli (*Brassica oleracea*): A review

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Abstract
Plants are a gift from nature to us that help us live healthy, disease-free lives and play a crucial role in protecting our well-being. The edible green plant known as broccoli or *Brassica oleracea* var. *Italica*, is a member of the Brassicaceae. It is thought that broccoli, *Brassica oleracea* var. *Italica*, is a nutritional hustler. Broccoli contains glucoraphin, sulforaphane, selenium and isothiocyanates. It is high in vitamin C and dietary fibre. Indole-3-carbinol can also be found in abundance in broccoli. Since they continue to possess a number of anti-cancer qualities and their benefits, these components found in broccoli are well recognized to be extremely popular. It is extensively utilised to treat different types of cancer as well as other neurological diseases. The phytochemical and medicinal potential of broccoli is covered the current review. The medicinal potential of broccoli has been discussed in relation to its use in the treatment of cancer, diabetes, and other major diseases. Brassinin, isothiocyanates, indole-3-carbinol and other phytochemicals similar to those found in broccoli have been shown to be very useful in the treatment of cancer. Glucosinolates, glucoraphin, and sulforaphane are a few more compounds that cause broccoli to produce more antioxidants activity. Broccoli sprouts contain sulforaphane, which has the potential to treat neurological conditions like Parkinson's and Alzheimer's disease. It is a good source of health promoting composite such Glucosinolates, flavonoids, hydroxycinnamic acid and vitamins according to a thorough review to the literature. Additionally, broccoli is a type of nutrient that has a vast range of beneficial effects, such as antioxidant, anti-cancer, hepatoprotective, anti-obesity, and anti-diabetic properties.

Keywords: Broccoli (*Brassica oleracea*), biological activities, phytochemistry

Introduction
The main source of pharmaceuticals for the early discovery of medicines is plants. In developing nations, about 80% of the population are still depends on plant extracts material as a source of medications. The World Health Organization (WHO) is promoting the traditional use of herbal medicines for the treatment of various habitual illnesses in developing nations due to increases in the risk of chronic sickness globally (Vasanthi *et al.* 2012) [40]. Adding more cruciferous vegetables to one's diet has been recommended by the American Cancer Society (1984) and the National Research Council (1982). These vegetables include cabbage, broccoli, brussel sprouts, cauliflower, and kohlrabi. *Brassica oleracea* var. *Italica*, or broccoli, is a fast-growing annual plant that reaches heights of 60 to 90 cm and is a member of the Brassicaceae family. It originates from the eastern Mediterranean and Asia Minor, and in the 1700s, it was later brought to England and America Anonymous (2015) [2]. Due to difficulties in patenting genotypes with high attention to glucosinolates showing favourable effects in the treatment of cancer, broccoli has attracted interest (Wolf *et al.* 2014) [43]. The majority of broccoli portions that are consumed as food are its florets, which account for 30% of the entire plant. Because of this, only flour and fibre are made from broccoli by-products such leaves and stems (Ares *et al.* 2013) [3]. However, it is becoming increasingly recognized in the scientific community that these by-products are valuable sources of phytochemicals (Bertelli *et al.* 1998) [9]. Additionally, more than 72% of the world's broccoli production are cultivated in Jeju and made in Korea. In addition to being produced in vast amounts, byproducts like leaves and stems from broccoli are also consumed in large quantities. This has a detrimental effect on the environment around agriculture and the recovery of those byproducts for physiologically active compounds that help to lessen environmental issues and boost growers profits (Borowski *et al.* 2008) [10]. Generally speaking, secondary metabolites with anti-microbial effects are known to be quite abundant in plants.

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The Evaluation of Security and Privacy Components in the Context of Peer-To-Peer Power Trading Methodologies using Network Intelligence

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Abstract: The widespread implementation of renewable energy sources, along with a more proactive approach to managing electricity use, is causing a shift in the way power systems operate and electricity is traded in the market. The P2P economy in particular is benefiting from this change. To efficiently handle the fast changes in renewable power generation at the distribution network level, a local market mechanism that can adapt is required. The efficient and safe operation of the distribution network is also bound to be affected by the extensive adoption of P2P energy trading. This study presents a new paradigm for P2P power trading that accounts for constraints imposed by distribution network security. Specifically, the design makes use of the generalised quick dual ascent method. The article lays out the groundwork for an event-based local peer-to-peer market, which would facilitate rapid and efficient energy swaps inside a certain region. The next step in making sure the distribution system is secure is to evaluate the impact of peer-to-peer transactions on the network using the nodal voltage and network loss in relation to nodal power injections. This allows for an internal determination of how to distribute the costs of P2P energy trading and the incorporation of the external operating constraints. Distributed market-clearing is also applied efficiently by means of a universal quick dual ascent technique. The numerical results show that the proposed model can implement P2P energy trading securely into the distribution system. Furthermore, the method for solving the problem shows remarkable efficiency in achieving convergence.

Keywords: *Peer-to-peer (P2P), Security, Privacy, Network Intelligence, Power Trading Methodologies*

1. Introduction

Peer-to-peer (P2P) power trading methods utilising network intelligence entail the transfer of electricity between individual users or prosumers within a decentralised energy system (Piclo, 2019). It is essential to prioritise the security and privacy of members in order to establish confidence and promote general acceptance of the network.

Global efforts are presently promoting the widespread use of solar power for self-consumption. This is done to decrease the need for investment and minimise operating losses in the transmission as well as the distribution network. Peer-to-peer (P2P) energy trading, an extension of self-consumption, allows prosumers to exchange energy through local distribution systems, potentially reducing strain on the transmission grid. Currently, the decentralised peer-to-peer energy trading market, exemplified by projects like (E. Mengelkamp,et.al., 2018) is becoming a viable choice due to recent advancements in technology for communications and information (C. Feng, et.al., 2020) . The primary objective of P2P sharing is to disrupt the conventional centralised hierarchical control paradigm of power networks and facilitate direct communication and distribution of energy.

2. Related Studies

Blockchain technology guarantees a high level of transparency and prevents unauthorised alterations in peer-to-peer power trading, hence improving the reliability and trustworthiness of transactions. Smart contracts on blockchain have the ability to automate and ensure compliance with the parameters of power trading agreements. (Narayanan, V., et al., 2016). Kshetri, N. (2018) Strong authentication systems, such as digital signatures and multi-factor authentication, are essential for confirming the identity of participants. Authorization, facilitated by either smart contracts or conventional access control techniques, guarantees that only authorised entities are able to participate in transactions. Methods such as homomorphic encryption and zero-knowledge proofs are effective in safeguarding the confidentiality of

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Role of IoT Intelligence System & Big Data Management to Control Flood Data

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Abstract: The increasing danger posed by floods requires the development of inventive strategies to ensure efficient management and reduction. This study explores the capacity for integrating Internet of Things (IoT) intelligence technologies and big data management to bring about significant changes in flood control tactics. Examining the interdependent connection between the Internet of Things (IoT) and big data, focusing on their functions in the areas of real-time monitoring, predictive analytics, and response mechanisms. The implementation of IoT sensor networks allows for the collecting of real-time data, while big data analytics enables the extraction of valuable insights from various datasets. The combination of these technologies holds the potential to completely transform flood control, equipping authorities with timely information to make proactive decisions. Nevertheless, the obstacles pertaining to data security, scalability, and standardisation necessitate meticulous deliberation. This paper seeks to examining & exploring the movements & process of using IoT intelligence systems and big data management to regulate flood data by thoroughly analysing case studies and technology applications.

Keywords: *: IoT, Intelligence System, Big Data Analytics, Control, Flood, Data*

I. Introduction

Integrating IoT intelligence systems with big data management could be a useful strategy for flood control. The Internet of Things (IoT) plays a vital role in flood monitoring by allowing for the collection of real-time data from several sources. The term "internet of things" (IoT) refers to the interconnection of many different types of sensors that gather data about the environment (Li et al., 2017). Johnson et al. (2019) states that these sensors deliver continuous data streams that enable accurate monitoring of environmental parameters in relation to flood episodes. In order for flood control methods to be effective, data collection and sensor networks must be deployed. The research suggests that in order to increase the geographical granularity of data collection, a dense network of sensors should be placed across flood-prone areas (Chen et al., 2021). Data on soil moisture, precipitation, and water levels should be collected in real-time so that potential floods may be predicted and responded to promptly (Tan et al., 2016). The seamless transfer of data between dispersed sensors and centralised data processing systems is made possible by the Internet of Things (IoT). Wireless communication technologies ensure that decision-makers obtain critical information in real-time, as stated by Zhang et al. (2020). In order to coordinate evacuations and react swiftly, this knowledge is critical. For flood prediction, advanced big data analytics are necessary because of the massive amounts of data generated by IoT devices (Kim & Lee, 2017). More accurate flood prediction models can be achieved by applying machine learning algorithms to datasets associated to floods, as discovered by Cheng et al. (2019). When it comes to flood control, the literature likely highlights the integration of GIS (Geographic Information System) with IoT and big data. Spatial analysis and mapping can help us better understand areas that are susceptible to flooding, possible routes of

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REVIEW ARTICLE

Phyto-remediation: An ecologically sound approach to revegetate heavy metal polluted land

Gayathri P.M*, Akshika Bhawariya, Rahul, Ravi Kumar, Shweta Singh

Gayathri PM, Bhawariya A, Rahul, et al. Phyto-remediation: An ecologically sound approach to revegetate heavy metal polluted land. AGBIR.2024;40(1):875-879.

Phytoremediation, that employs hyper-accumulator plant species that are incredibly tolerant to Heavy Metals (HMs) present in the environment or soil, is a feasible and promising method for removing HMs from contaminated environments. This method uses green plants to eliminate, break down, or detoxify dangerous metals. The procedure is simple, efficient, and cost-effective, with widespread implementation on a big scale. Nowadays, phytoremediation is a highly effective approach but its efficacy is largely dependent on the choice of plant species. The purpose of this study is to acquire some information regarding the sources and effects of the heavy metals arsenic, lead, and mercury (As, Pb, and Hg). It also provides a thorough analysis of phytoremediation technology, covering heavy metal uptake mechanisms and a number of related research findings.

Key Words: *Phytoremediation; Heavy metals; Hyper-accumulator; Lead; Mercury*

INTRODUCTION

The build-up of heavy metals in soils and waterways poses a risk to both environmental and human health. These substances accumulate in the body tissues of living organisms through bioaccumulation, and their levels intensify as they progress from lower to higher trophic levels, a phenomenon referred to as bio magnification. The presence of heavy metals in the soil can have toxic effects on soil microbes, ultimately leading to a decrease in their numbers and functional capabilities [1]. The remediation of soil for the preservation of ecosystem processes and functions represents one of the key challenges confronting our society today.

LITERATURE REVIEW

Chemical methods employed for the decontamination of Heavy Metals (HMs), encompassing precipitation, heat treatment, excavation, electro remediation, and chemical leaching, remains an expensive process and are dependent on both soil and pollutant properties [2]. The key drawbacks and constraints of these approaches include the alteration of soil characteristics particularly pH, potential threats of soil fertility decline, challenges in small-scale implementation, and the generation of by-products. Phytoremediation, an environmentally benign method, is a cost-effective strategy for mitigating heavy metal contamination and revegetating contaminated soil. It involves utilizing hyper accumulator plants and their associated rhizospheric microorganisms to stabilize, transfer, or break down pollutants within soil, water, and the surrounding environment [3]. Plants, through their root system, have the potential to engross ionic complexes from the soil even at low concentrations. For the accumulation of heavy metals and regulate their bioavailability, plants spread their root systems into the soil matrix and create rhizosphere ecosystems, which stabilize soil fertility and allow for the reclamation of polluted soil. By considering the soil's conditions, pollutant attributes and the type of plants used. Five phytoremediation techniques have been employed: Phytodegradation, phytofiltration, phytoextraction, phytostabilization, and phytovolatilization (Figure 1). The simplest method for phytoremediation is utilizingheavy metal hyperaccumulators. Plants are classified as tolerant and/or hyper accumulator to Heavy Metals (HMs) when they exhibit accelerated growth, high biomass, and the capability to extract and amass significant quantities of HMs in their shoots, all without demonstrating signs of toxicity when cultivated in contaminated soils with these metals [4]. In light of this, the incorporation of this green technology emerges as a powerful strategy for remediating soils or agro-ecosystems impacted by Heavy Metal (HMs) contamination.

A detailed examination has been undertaken to provide an extensive overview of various dimensions of phytoremediation. The analysis provides a detailed account of the application of various macrophytes for pollutant removal, particularly focusing on heavy metals.

Heavy metals: Source and their consequences

Elements with densities >5 g/cm^3 are described as heavy metals [5,6]. Heavy Metals (HMs) possess a half-life exceeding twenty years, demonstrating their remarkable persistence [7-9]. HMs occur naturally in rocks, but human activities have elevated their presence. The excessive application of sewage sludge, agrochemicals, wastewater, bio solids, and manure serves as a substantial source of HMs in soil [10]. Hazardous heavy metals such as Hg, As, Cd, Pb, Cr, Cu, and others are commonly present in wastewater originating from sources like mines, sewage, dyes, and alloys [11]. Heavy Metals (HMs) are divided into two categories: Essential and non-essential. Elements such as Cobalt (Co), Copper (Cu), Chromium (Cr), Iron (Fe), Nickel (Ni), Manganese (Mn), and Zinc (Zn) fall under the essential HMs, serving as micronutrients but turning toxic with excessive consumption. On the other hand, Cadmium (Cd), Mercury (Hg), and Lead (Pb) are non-essential HMs, posing extreme lethality to living organisms [12]. Anthropogenic activities have a more significant impact on environmental pollution than natural sources [13]. Heavy metal accessibility in the soil solution is influenced by factors such as the metal's nature, soil attributes (like pH, clay content, and organic matter), and exchange reactions, encompassing processes such as precipitation and adsorption-desorption [14,15]. In addition to the above-mentioned sources, heavy metal pollution is exacerbated by the presence of cosmetics and chemical fertilizers [16].

Consequences of heavy metal pollution

The accelerated global development and urbanization have amplified the possibility of heavy metal contamination in ecosystems [17]. According to literature, about 10 million people globally have been affected by soil contaminated with heavy metals [18]. The growing prevalence of heavy metals in soils is worrisome, not only for plant growth and productivity but also due to the potential health threats to both humans and animals [19]. Plant growth is adversely affected by heavy metals, leading to a decline in both physiological and morphological responses, disruption of nutrient uptake processes, and ultimately reducing plant yield [20,21]. Heavy metals negatively affect plant growth by decreasing chlorophyll content, inducing chlorosis and necrosis, and resulting in plant death through decreased chlorophyll content and stomatal closure [22,23]. Human health is negatively affected by heavy metals, and consequently, several heavy metals and metalloids can pose dangers even at lower concentrations [24-26]. The presence of heavy

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Studies on heterosis of different yield and its attributing traits in pumpkin (*Cucurbita moschata* Duch ex Poir)

Mahendra Kr. Yadav[1*], Satyendra Kumar[2], Juri Das[3]

Yadav MK, Kumar S, Das J. Studies on heterosis of different yield and its attributing traits in pumpkin (*Cucurbita moschata* Duch ex Poir). AGBIR.2024;40(1):869-874.

The investigations were carried out to evaluate the 28 F1 of pumpkin (*Cucurbita moschata* Duch. Ex Poir.) at Department of Vegetable Science, Kalyanpur, CSA, University of Agriculture and Technology, Kanpur (U.P.) during Zaid 2021. The experiments were laid out in randomized complete block design with three replications. The data were recorded for 19 characters traits *viz*., days to first male flower appearance, days to first female flower appearance, node numbers to first male flower appearance, node numbers to first female flower appearance, vine length, internodal length, branches plant-1, days to first harvest, average fruit weight, fruits/plant, equatorial circumference of fruit, polar circumference of fruit, flesh thickness, total soluble solids, dry matter content, moisture content, seed/fruit, Specific gravity and fruit yield/plant. Highest fruit yield per plant was recorded in best hybrids *viz*. Azad Pumpkin-1 × P-40-16, Azad Pumpkin-1 × Punjab Samrat, P-40-16 × Punjab Samrat Azad Pumpkin-1 × P-35-16, Narendra Agrim × Punjab Samrat and Azad Pumpkin-1 × DVRP-2-5) in F1, exhibited significant and desirable heterosis in better parent with days to first male flower appearance, days to first female flower appearance, node number to first female flower appearance and days to first fruit harvest.

Key Words: *Pumpkin; Heterosis; Better parent; Fruit yield*

INTRODUCTION

Pumpkin (*Cucurbita moschata* Duch ex Poir) is an economically important vegetable crop. It is hardy in nature and rich in carotene content and also have very good keeping quality. It is an herbaceous annual sexually propagated vegetable having an identical genomic structure i.e., AABB which indicates that it is an amphidiploid. It comprises about 27 species of both wild and cultivated having same chromosome number of 2n=40. Among these species only five species *viz*., *Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita ficifolia*, *Cucurbita pepo* and *Cucurbita mixta* are commonly cultivated. Robinson and Decker-Walters [1] concluded that in genus Cucurbita there are 5 cultivated and 10 wild species. Seshadri and More also stated that the recent recognition of synonyms and taxonomic changes have reduced the number of Cucurbita species to 15 or even less. The crop improvement can be brought about in pumpkin by assessing the genetic variability and exploitation of heterosis. Because of the monoecious nature of the crop, large flower size, easy of pollination, high proportion of fruit set of pollinated female flowers, large number of seeds per fruit and low seed rate required per unit area, pumpkin is highly amenable for heterosis breeding. It has ample scope for successful exploitation of hybrid vigour. Information on the magnitude of heterosis in different cross combination is a basic requisite for identifying crosses that exhibit high degree of exploitable heterosis. The magnitude of heterosis in different crosses and its confirmation through inbreeding depression in F2 generation and then utilization in future crop improvement programmes [2]. Studies on hybrid vigour and high amount of heterosis in pumpkin has been reported by many research workers [3-7]. Several hybrids have been released by public as well as private sectors for its commercial cultivation. The area under F1 hybrids is growing fast, which has helped to enhance the productivity and production of this crop.

MATERIALS AND METHODS

The investigations were carried out to evaluate the 64 genotypes (28 F1, 28 F2 and 8 parental lines) of pumkin *viz*: Azad Pumpkin-1 (P1), P-35-16 (P2), P-40-16 (P3), Narendra Agrim (P4), NDPK-7-24 (P5), Kashi Harit (P6), DVRP-2-5 (P7), and Punjab Samrat (P8). The 8 parental lines and their 28 F1 were grown in a randomized complete block design with three replications during Zaid 2021 at the Main Experiment Station, Department of Vegetable Science, Kalyanpur, CSA University of Agriculture and Technology, Kanpur (U.P.). Each 28 F1, F2 and parents were grown in rows spaced 3 meters apart with a plant to plant spacing of 0.50 meter. All the recommended agronomic package of practices and plant protection measures were followed to raise good crop. Observations were recorded on nineteen quantitative traits *viz*., days to first male flower appearance, days to first female flower appearance, node numbers to first male flower appearance, node numbers to first female flower appearance, vine length, internodal length, branches plant-1, days to first harvest, average fruit weight, fruits/plant, equatorial circumference of fruit, polar circumference of fruit, flesh thickness, total soluble solids, dry matter content, moisture content, seed/fruit, Specific gravity and fruit yield/plant. The data recorded from 28 F1, 28 F2 and 8 parental lines on nineteen characters were subjected to estimate heterosis expressed as per cent increase or decrease in the mean values of F1's (hybrid) over better-parent (heterobeltiosis) and standard variety (standard heterosis) was calculated according to method suggested by Hayes et al., [8].

RESULTS AND DISCUSSION

The results of the study reveals that the heterosis was estimated as per cent increase or decrease of F1 values over the Better Parent (BP). The estimates of better parent heterosis for all the traits in twenty-eight F1 are presented in Table 1.

Out of twenty-eight F1 hybrids, five crosses showed significant and negative heterosis over better parent for days to first male flower appearance which were best five crosses, NDPK-7-24 × Punjab Samrat followed by Azad Pumpkin-1 × Punjab Samrat, P-40-16 × DVRP-2-5, P-40-16 × Punjab Samrat and Azad Pumpkin-1 × P-40-16. Nineteen crosses showed significant and negative heterosis over better parent for days to first female flower appearance which were NDPK-7-24 × Kashi Harit followed by Narendra Agrim × NDPK-7-24, Kashi Harit × DVRP-2-5, Narendra Agrim × DVRP-2-5 and Azad Pumpkin-1 × Kashi Harit. Eleven crosses showed significant and negative heterosis over better parent for node to first male flower appearance which were P-40-16 × NDPK-7-24 followed by P-40-16 × Punjab Samrat, P-40-16 × Narendra Agrim, NDPK-7-24 × Punjab Samrat and Kashi Harit × Punjab Samrat. Seven crosses showed significant and negative heterosis over better parent for node to first female flower appearance which were Azad Pumpkin-1 × Punjab Samrat followed by Narendra Agrim × DVRP-2-5, P-40-16 × Punjab Samrat, Narendra Agrim × Punjab Samrat and NDPK-7-24 × Punjab Samrat. Six crosses showed significant and positive over better parent for vine length which are P-40-16 × NDPK-7-24 followed by P-40-16 × Narendra Agrim, P-35-16 × Kashi Harit, P-40-16 × DVRP-2-5 and Azad Pumpkin-1 × DVRP-2-5. Six crosses showed significant and negative heterosis over better parent for

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RESEARCH ARTICLE

Exploring the impacts of varied natural and organic farming approaches on growth attributes and yield of wheat (*Triticum aestivum* L.) based intercropping systems in the sub humid climatic conditions of Himachal Pradesh

Raveena[1,2*], Rameshwar Kumar[2], Shilpa[3]

Raveena, Kumar R, Shilpa. Exploring the impacts of varied natural and organic farming approaches on growth attributes and yield of wheat (*Triticum aestivum* L.) based intercropping systems in the sub humid climatic conditions of Himachal Pradesh. AGBIR.2024;40(1):827-833.

A field experiment was conducted during rabi 2021 at the Zero Budget Natural Farm (ZBNF), Department of Organic Agriculture and Natural Farming, COA, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, to compare the effect of natural and organic farming techniques on the growth and yield of wheat. The study employed a randomized block design with thirteen treatments replicated three times. The results showed that the treatment comprised of wheat+gram and jeevamrit spray at 14 days' interval led to significantly greater growth attributes, viz., plant height at 90, 120, 150 DAS and at harvest (32.3, 63.5, 89.7 and 92.1 cm) and number of tillers per square meter at 90, 120, 150 DAS and at harvest (193.7, 232.4, 222.1 and 214.5) of wheat. Similarly, the treatment wheat sole and jeevamrit spray at 14 days' interval resulted in significantly higher grain and straw yields (16.07 q/ha and 30.53 q/ha). The highest wheat equivalent yield (18.37 q/ha) was achieved using organic farming practices wheat+gram and matka khad spray at 30 days' interval followed by wheat+lentil and matka khad spray at 30 days' interval (17.07 q/ha). Therefore, it was concluded that treatment comprised of organic package of practices along with the application of matka khad at 30 days' interval was found to be the best treatment with respect to crop growth and productivity of main crop as well as intercrops. In conclusion, the most effective treatment for crop growth and productivity, both for the main crop and intercrops, was found to be the organic approach with matka khad application at 30-day intervals.

Key Words: *Growth; Jeevamrit; Matka khad; Natural farming; Organic farming; Yield*

INTRODUCTION

Over the past 50 years, significant increases in wheat yield have been realized through changes in agricultural practices. These changes include the widespread use of synthetic fertilizers and pesticides, as well as the development of crop varieties adapted to these conditions. Notably, the introduction of dwarfing genes has played a pivotal role in enhancing wheat yield by improving the harvest index [1]. However, in recent years, it has become increasingly apparent that a yield plateau has been reached for many crops [2]. This plateau means that the traditional methods of boosting crop yields are no longer as effective, and we need to find new approaches to maintain and increase yields sustainably. This is a pressing concern, given the world's growing population, which is expected to reach 9 billion people by 2050. As the population expands, there will be competing demands for land, including its use for energy production. Therefore, it's imperative to find ways to meet the world's food needs while preserving the environment and ensuring the sustainability of agricultural practices.

Traditional farming heavily depends on using various modern management methods and external resources to achieve high crop yields [3]. Unfortunately, a consequence of this approach has been the development of resistance to pesticides in recent years [4-6]. Additionally, the intensive use of pesticides and synthetic fertilizers has led to environmental problems [7]. Some pests have become resistant to control methods like resistance genes and pesticides faster than new solutions can be developed [8], particularly in the case of wheat. This growing pest issue is happening at a time when important pesticides are being phased out and resistance genes are weakening because of extensive farming and climate change [9]. Furthermore, changes in the EU Pesticide Directive (91/414/EEC) are expected to have significant effects on crop production in member states. These changes will require the removal of roughly 20% of active ingredients in the near future [10]. This means that more food will need to be produced using fewer pesticides.

Ensuring continuous crop productivity on arable land for future generations while preserving the environment is a critical challenge. Organic farming aims to avoid the regular use of synthetic fertilizers, pesticides, and growth regulators [11,12]. To achieve this, it relies on practices such as crop rotation, cultivation methods, appropriate sowing schedules, and the use of resistant crop varieties. Low-input and organic farming systems typically result in lower and more variable crop yields. This is because they involve longer crop rotations and reduced use of fertilizers and pesticides [13].

Compared to conventionally managed farms, organic farms have richer and more diverse populations of helpful organisms in their soils. Organic farming results in a 20-30% increase in microbial biomass and a 30-100% boost in microbial activity [14]. However, it's important to recognize that organic farming demands substantial inputs like farmyard manure, green manure, compost, and vermin-compost to provide the necessary nutrients for crops. This can be a challenge for small and marginal farmers, particularly those with limited livestock. They often have to purchase bulky organic fertilizers from outside sources, incurring additional transportation costs on top of their cultivation expenses. In such cases, this practice can become financially unsustainable for them. To address this issue, "Padma Shree Subhash Palekar" introduced an innovative concept called "Zero Budget Natural Farming (ZBNF)." ZBNF is a farming approach that requires minimal external inputs and doesn't rely on credit. It makes use of locally available resources and effectively reduces production costs while increasing crop yields. This approach aims to make farming financially viable for small and marginal farmers, allowing them to grow crops sustainably without the burden of excessive expenses. Zero Budget Natural Farming (ZBNF) comprises four fundamental components: Beejamrit: This involves coating seeds with a mixture of cow dung and urine. It's a natural way to enhance seed quality

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REVEALING THE FUNDAMENTAL FACTORS BEHIND ENTREPRENEURSHIP

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Introduction

Becoming an entrepreneur is a tough journey, with failure being a common outcome unless one consistently performs at their best. Merely 10% of newly established businesses survive their second year, often leaving entrepreneurs on the unsuccessful side of the spectrum. This failure stems from various challenges including operational issues, staffing problems, financial constraints, and timing issues such as peaking too soon or too late. This article also delves into the top five causes of entrepreneurial failure, all of which highlight deficiencies in venture management and a lack of efficiency in day-to-day operations.

Additionally, overlooking the bigger picture due to excessive focus on details, failing to grasp the essence due to an obsession with particulars, and neglecting crucial details are other recurrent issues explored in these discussions.

Issues with Finance

The initial factor relates to financial challenges. It's widely understood that startups and emerging businesses require funding at every phase of their growth. Therefore, entrepreneurs must secure support from financial institutions and venture capitalists from the outset and sustain this support over time.

Entrepreneurs often encounter setbacks when their promising ideas fail to translate into revenue or attract business, causing venture capitalists to lose interest and withdraw their support. Additionally, some businesses and their founders fail to foresee the ongoing cash flow required to sustain the business's viability.

Manpower Issues

The second reason for business failure is understaffing; when a company first opens, it frequently lacks the resources it requires because of this. For instance, as businesses expand or take on new projects, they usually need more resources these days. However, as they require time and money to manage, having too many resources could make an undertaking more challenging. In addition, lacking the necessary resources because they are too costly or unwilling to assume the risk of working for a startup. Yes, those giddy dotcom days are long gone, when nearly everyone aspired to be employed by a corporation. Many workers these days don't want to risk their careers by taking jobs with unidentified companies.

"Stranded in the Desert: The Brutal Truth of the Entrepreneurial Cash Crunch and Liquidity Drought"

The third prevalent reason why young companies fail is poor financial management, specifically with regard to cash flow. This is a result of many business owners not being able to predict the cash shortfalls brought on by an imbalance in accounts payable and accounts receivable. Furthermore, young companies frequently build their present budgets on anticipated future earnings, which leaves them open to depletion in the event that such earnings do not materialize. Furthermore, difficulties with liquidity may worsen if venture capitalist funding is abruptly stopped. Current shutdowns in the Indian aviation sector are harsh reminders that, although an enterprise can postpone paying bills, it cannot postpone paying suppliers, employees, or vendors since these parties depend on prompt performance of obligations.

Mismanagement in Operations

Operational mismanagement ranks as the fourth leading factor contributing to the failure of fledgling businesses. This arises when entrepreneurs find it challenging to efficiently supervise the complex operational aspects of their ventures. For example, numerous business proprietors choose to assign daily operational tasks to others, focusing on strategic planning instead. While micromanaging isn't

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RESEARCH ARTICLE

Enhancing tomato wilt resistance through organic soil amendments: A comprehensive study on the impact of various treatments

Sarita, Sunita Bhandari*, Shweta Singh

Sarita, Bhandari S, Singh S. Enhancing tomato wilt resistance through organic soil amendments: A comprehensive study on the impact of various treatments. AGBIR.2024;40(1):846-849.

Tomato (*Solanum lycopersicum*) holds considerable significance in Indian cuisine but its production faces challenges from various biotic stressors, with *Fusarium* wilt being a major concern. This study assesses the efficacy of diverse soil amendments (Karaj oil cake, Linseed cake, Bone meal, Horne meal, Vermicompost, Poultry manure, Blood meal and Mustard cake) in combating *Fusarium* wilt in tomato plants. Ten distinct treatments were administered to analyze their impact on multiple growth parameters, including shoot length, root length, seedling length, fresh shoot weight, fresh root weight, fresh seedling weight, and wilt intensity. The findings revealed notable enhancements in growth parameters among treated plants compared to the control. Treatments T_5 (*Fusarium oxysporum*+Vermicompost) and T_6 (*Fusarium oxysporum*+Poultry manure) demonstrated the highest percent control, with values of 56.5% and 56.2%, respectively. Promisingly, treatments involving and demonstrated higher control percentages, offering potential sustainable and ecofriendly solutions for managing *Fusarium* wilt of tomato crops.

Key Words: *Soil amendments; Length; Growth; Sustainable; Wilt; Ecofriendly*

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most versatile vegetable with wide usage in Indian culinary tradition [1]. It belongs to the genus Lycopersicon under Solanaceae family. Tomatoes are a prominent vegetable crop that has grown in popularity over the previous century. The number of biotic and abiotic stressors in tomato production is a restriction. Anthracnose, phytopthora, leaf blight, *Fusarium* wilt, bacterial wilt, damping-off, and root rot are some of the most common diseases that damage tomato production. *Fusarium* wilt, caused by the *Fusarium oxysporum* fungus, has recently arisen as a severe concern [2-5]. The major disease contributing to the loss in the production of this important crop is *Fusarium* wilt, which is caused by pathogenic formaespecialis i.e., *lycopersici* of the soil-inhabiting fungus *Fusarium oxysporum* (Sacc.) W.C. Synder and H.N. Hans. [6]. *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) W.C. Synder and H.N. Hans is the major limiting factor in the production of tomato. These pathogens prove challenging, primarily because of their enduring presence in the soil and their ability to infect the vital vascular tissues and subterranean parts of plants. Complicating matters is the absence of registered fungicides, highlighting the urgent need for effective and environmentally friendly alternatives. Various strategies have been experimented, both in laboratory settings and tomato greenhouses. These include exploring indigenous fungi and bacteria [7,8], fungal and bacterial endophytes [3,5], aqueous and organic extracts [9], resistant rootstocks [4,10], composts [11], and various resistance inducers [12]. Farmers are nonetheless facing increasing pressure from soil borne diseases in spite of these efforts. Because of persistent tomato cultivation in the same fields, favorable weather conditions for diseases, common cultural methods, and the introduction of novel pathogenic strains, these pathogens frequently reach significant concentrations in the soil [2-4]. Because of its effects on beneficial species and potential harm to human and animal health, the use of chemical pesticides to manage *Fusarium* wilt and other soil-borne infections has a number of disadvantages. As a result, the emphasis now is on creating lasting, other strategies for controlling these infections. Since soil additives have the ability to alter the rhizospheric microbial community's composition, which in turn affects the soil's resistance to pathogens, they have emerged as a viable tactic to accomplish this goal. For example, studies on the effects of organic manures on soil microbial community manipulation and effective control of soil-borne diseases have been shown.

Several studies have investigated the intricate mechanisms through which the addition of organic materials can bring about these changes in the soil microbial community. Understanding these mechanisms is crucial for optimizing the use of organic amendments in agriculture. This research has shed light on how organic materials influence the microbial ecology of the soil, impacting the abundance and diversity of various microbial populations. This information can help design focused and efficient strategies to improve soil health and inhibit the spread of dangerous diseases. Overall, maintaining the long-term health and productivity of agricultural systems while minimizing harm to the environment and human health calls for a shift towards sustainable and environmentally conscious methods for addressing soil-borne diseases like *Fusarium* wilt.

MATERIALS AND METHODS

The study titled "Enhancing tomato wilt resistance through organic soil amendments: A comprehensive study on the impact of various treatments" was conducted in the Plant Pathology laboratory in collaboration with the Plant Breeding department at RNB Global University, Bikaner, in 2023. Effect of soil amendments on tomato wilt was evaluated and treatments were: T_1 (*Fusarium oxysporum*+Karaj oil cake), T_2 (*Fusarium oxysporum*+Linseed cake), T_3 (*Fusarium oxysporum*+Bone meal), T_4 (*Fusarium oxysporum*+Horne meal), T_5 (*Fusarium oxysporum*+Vermicompost), T_6 (*Fusarium oxysporum*+poultry manure), T_7 (*Fusarium oxysporum*+Blood meal), T_8(*Fusarium oxysporum*+Mustard cake), T_9 (*Fusarium oxysporum*) and T_{10} Control. Tomato selection-7 was sown in the pots (Four numbers of sets were maintained) and the statistical design is CRD. The experimental soil was combined with various treatment components in 1:3 ratios. Pots were left for a month following the soil amendment experiment. Data were collected on the percentage of seedlings at 18 Days After Sowing (DAS), the wilt intensity was observed at various DAS, and the growth characteristics of the seedlings, including shoot length, root length, height, fresh shoot root, and seedling weight at 30 DAS.

Isolation of pathogen

The collected diseased sample was washed properly with distilled water. Infected tissues along with adjacent small unaffected tissues from this sample were cut into small pieces (2-5 mm) in aseptic condition and then with the help of flame-sterilized forceps transferred to a sterile Petri plate containing 0.1 percent HgCl2 (mercuric chloride) and immersed it for 30-60 seconds. Then in the distilled water pieces were washed 2-3 times serially to remove traces of mercuric chloride. 2-3 pieces were transferred aseptically to Petri plates (containing PDA) and then plates were incubated at 28 ± 1°C and

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RNB Global University Registrar Bikaner

AI REVOLUTIONIZING CONTENT DIVERSITY AND CULTURAL SENSITIVITY IN INDIA

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Abstract:
Artificial Intelligence (AI), with its ability to analyze vast amounts of data and generate personalized content, has the potential to revolutionize the digital landscape in India, impacting both content diversity and cultural sensitivity. Its algorithms have been increasingly efficient in identifying biases and other unethical practices in the countless hours of video and audio content uploaded to the internet through various popular content platforms. It has also been a driving force behind the much-needed structural changes in the Indian society in terms of culture sensitivity and acceptance. This paper provides an overview of the current state of the art of AI and discusses how AI has impacted content diversity.

Keywords: Artificial Intelligence (AI), Content diversity , Cultural sensitivity, Indian society, Digital landscape

1. Introduction

India is a country with a population of more than a billion and a rich tapestry of diversity. The landscape of India is as diverse and different as its people, whose languages, culture, art and literature manifest the distinctiveness that characterizes its many traditions. Today, this veritable supermarket of languages and cultures coexists in the digital space of a shrinking world, sharing the consumer shelves with the best of global content providers. In India, this interplay of local linguistic content and the global one is all set to receive a makeover of sorts due to the entry of the latest knowledge technology. Artificial Intelligence (AI), with its ability to analyze vast amounts of data and generate personalized content, has the potential to revolutionize the digital landscape in India, impacting both content diversity and cultural sensitivity. Introduction of artificial intelligence in this growing landscape is sure to make ripples far and wide due to its potential to transform the way content is generated and disseminated.

1.1. Background of AI technology

Artificial Intelligence is the intelligence demonstrated by machines imitating human cognitive functions. AI has transformed the global landscape since antiquity. It began taking shape in the 21st century, with devices like robot vacuum cleaners, smartphone assistants, self-driving cars, and recommendation systems. With big data, AI has revolutionized every industry. Integration of AI is now a matter of extent and utilization.

1.2. Importance of content diversity and cultural sensitivity

Essentially, the increasing use of AI-powered tools holds the potential to significantly transform content across a wide range of media offerings, in terms of both content and presentation. In particular, the use of AI to better understand the extensive, diverse and often complex cultural landscape of India can ensure that the content is well suited to the preferences and sensibilities of its vast population. Most importantly, this can help ensure the deployment of a range of media platforms that correlates with the people's preference, language choice and cultural nuances all across the nation. Indian media has time and again been called out for not being truly representative of what is envisioned in the Constitution of India as determined and appreciated in the preamble. Understanding how AI can enhance cultural sensitivity and ensure diversity in content can be a good step forward to changing the present scenario in the nation.

1.3. Significance of studying the impact in India

India offers an ideal opportunity to study the application and impact of AI in multi-lingual, multi-cultural and diverse society. The growing digitisation of services and transactions, increased internet access and deepening of the digital economy is driving an ever growing demand for technology which can understand, interpret and generate content for the diverse set of consumers.

RNB Global University Registrar Bikaner

AI AND CULTURAL HERITAGE PRESERVATION IN INDIA

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Abstract:
Cultural heritage preservation is crucial for maintaining and respecting the diversity prevalent in India. The preservation of cultural heritage sites and artefacts is vital for promoting the ongoing cultural and social heritage. The use of artificial intelligence (AI) in cultural heritage preservation in India has been increasing. AI has been used to categorize artifacts and predict their preservation needs by analyzing the deterioration pattern. Moreover, the use of AI in replication of broken artwork is helping to repair the broken objects to an extent and allowing the utilization of these broken pieces in the best approach plausible. The purpose of this paper is to highlight the advantages of using AI in the documentation, preservation, and conservation of culture heritage sites in India for several reasons.

Keywords: Artificial Intelligence (AI), Cultural Heritage, preservation, Diversity, Heritage Sites, Artifacts

1. Introduction

The Intangible Cultural Heritage (ICH) reflects a community's cultural heritage and it should be passed on from generation to generation. In the rapidly advancing technology age, the cultural heritage is not just forgotten, but is also getting destroyed, too. According to The Hindu, temples are looted and ruined in India due to lack of adequate security measures to preserve the invaluable artifacts; and oftentimes due to ignorance. According to India Today article, 9% of the 122 "centrally protected monuments, groups of monuments and sites" in India and 35% of the 3,678 "state protected monuments" in north India are "untraceable". India is rich with diverse-invaluable intangible and tangible cultural heritage. It is the need of the hour, to explore innovative methods for preserving endangered cultures in India and other developing communities.

1.1 Importance of Cultural Heritage Preservation

India is an immensely cultured country, rich in its history and its tradition. Uncovering millennia of history, there is something to learn from every nook and corner. From the frozen lands of the Himalayas to the lush green south, the country boasts of various inherited pieces of culture that need to be preserved. There are various megaliths, temples, forts, palaces, churches, mosques and gurudwaras, with varied communities and groups, covering the time span of hundreds of years. Each of these communities have various stories of various battles, pilgrimages and journeys that are showcased through various artefacts, scriptures and ancient elements that need to be persevered. Every geographical area of India has various cultures and each of their significances are very prominent historically and archaeologically.

1.2 Role of AI in Cultural Heritage Preservation

Artificial intelligence has seemingly endless applications in the field of cultural heritage. The preservation of cultural heritage entails the restoration, documentation and protection of traditions, artwork, historical artefacts and traditions, and as it is obvious, this is a great challenge. AI can completely transform the way we think of preservation. There are drones that fly, inspect the sites of heritage and work with artificial intelligence for surveillance, mapping and modelling. There are linguistically capable chatbots that can communicate across various languages, offering foreign visitors insights into the area they are in. with the automatic classification of the work of art, AI that could revolutionise crucial documentation and information is being researched. Model perception and interpretation, such as the example of Google Cloud Vision that provides API access to the image recognition unit, and finally, chatbots for customer engagement and commitment.

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AN IN-DEPTH ANALYSIS OF THE UPI PAYMENT SYSTEM IN INDIA

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Abstract:
The Unified Payments Interface (UPI) in India is a major platform that facilitates online money transfer between two parties using a smartphone. This innovative method enhances the accessibility and efficiency of payment systems, and holds significant potential for emerging markets and developing nations. As UPI continues to develop, more and more Indian citizens are embracing this transformative payment system, propelling India into the digital era with impressive momentum and progress. Additionally, research will demonstrate the lasting social and sociological impacts of the UPI system in India.

Keywords: UPI, Smartphone, Payment System, Developing Countries, Digital Age

1. Introduction

The Unified Payments Interface (UPI) perational in India is a major platform that permits the momentum of online money transfer between any two parties with a smartphone. It results in immediate monetary transactions that ease not only the settlements between business houses and their customers, but also the hassle-free payment to individuals for their day-to-day activities. Furthermore, the UPI service providers can link to multiple bank accounts and thus make it easier for the consumers to complete any transaction. Thus, UPI has made a paradigm shift in the payment processing scenario in India. The UPI has made the cause of cashless, effortless, and safe transactions successful. In the coming sections, the neologisms and technical acrimony are explained for an easy and clear understanding of payment systems prevalent in the country today. [1] [2] [3] [4] [5] [6] [7]

1.1. Background

The Reserve Bank of India has launched a major initiative to enable internet banking through mobile phones. This groundbreaking move is aimed at providing customers with an additional channel for conducting banking activities, making it even more convenient and accessible. The development of a mobile-based payment system brings forth a multitude of benefits, allowing account holders to easily and securely carry out transactions through their mobile phones. This innovative approach not only enhances the accessibility and efficiency of payment systems, but also holds great potential for emerging markets and developing countries. In India, where mobile phone usage exceeds that of traditional banking methods, mobile payments have emerged as a promising solution for transitioning towards a cashless society. Despite low transaction volume presently, mobile payments are steadily gaining traction and proving to be a transformative force in the financial landscape.

In order to ensure seamless connectivity and uninterrupted service, the principal bank branches are equipped with round-the-clock access via a secured web access channel that is directly linked to the Core Banking System (CBS). The CBS acts as the central hub for processing transactions made by bank customers, both incoming and outgoing. To guarantee utmost security, these transactions are encrypted and transmitted through highly secure communication gateways. By leveraging this robust infrastructure, the Reserve Bank of India is setting the stage for a future where mobile banking

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DATA MINING AND DATA WAREHOUSE: AN IN-DEPTH REVIEW

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Abstract:
Data warehousing and data mining are crucial aspects of modern businesses. Data mining is the process of identifying patterns in data and using these patterns to derive useful information. A data warehouse is a database applications system designed to report and analyze data. Data warehousing is a vital building block in the decision-making process. The secondary aim is to analyze the major success and failure factors in data warehousing projects, as well as to study the potential challenges for the vendors, consultants, implementers, and the academic researchers to delve into it so that future strategies can be developed for the successful implementation of data warehousing in organizations. It is the recommendation of the group that changes in philosophy and policy must match changes in the environment and changes in system design and procedures. Other recommendations include the creation of a single approval plan for electronic and print resources, and establishment of a system for notification of electronic serial purchases.

Keywords: Data Warehouse, Data Mining, Vendors, System Design, Environment

1. Introduction

Data warehousing and data mining are crucial aspects of modern businesses that are similar conceConcepts and systems. They are both used to offer value to organizations and their data in varied ways. A data warehouse is a database applications system that is designed to report and analyze the contents of a series of different databases. In other words, a data warehouse is only as good as the information that is put into it, and extracting good information from a data warehouse is also relative to the data input into it. Are crucial aspects of modern businesses that are similar concepts and systems.

1.1. Definition of Data Mining

Data mining is a systematic procedure utilized to convert unprocessed data into valuable knowledge. A pivotal aspect of data mining involves creating an algorithm that can efficiently analyze extensive quantities of information to identify patterns.

1.2. Definition of Data Warehouse

A data warehouse is a system used for reporting and data analysis and is considered as a core component of a business intelligence environment. Due to the varying definitions of this system, it is considered as a vital pivotal building block in the decision-making process within an organization. Data in the data warehouse system is not frequently updated, therefore smaller organizations may not have a data warehouse unless they have other analytical systems available. Data warehouses are systems that are designed for query and analysis rather than transaction processing, and they usually contain large amounts of historical data.

1.3. Importance of Data Mining and Data Warehouse

Today, in this fast-moving world, we have an information overload and access to this information in a quick and reliable manner is of utmost importance to companies, so that decisions can be taken

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REVIEW ARTICLE

The role of agroforestry in mitigating climate changes in arid regions of Rajasthan

Gayathri P.M*, Akshika Bhawariya, Anil Swami, Raveena

Gayathri PM, Bhawariya A, Swami A, et al. The role of agroforestry in mitigating climate changes in arid regions of Rajasthan. AGBIR.2024;40(1):861-864.

Climate conditions of northwest regions hinder production and life support system. The people in this region have developed an agroforestry-based drought protection system through generations of experience and ingenuity, that has been passed down from generation to generation. Agroforestry systems are environmentally and economically sound farming practices that improve overall farm productivity, enrich soil with fallen litter, and preserve environmental services like phytoremediation, biodiversity conservation, watershed protection, and carbon sequestration-all of which help to mitigate climate change. Agroforestry systems possess substantial potential for offering effective mitigation options; however, their capacity to sequester carbon depends heavily on well-managed practices. This paper describes the traditional agroforestry systems that prevail in the arid regions of Rajasthan and their role in mitigating climate change.

Key Words: *Carbon sequestration; Phytoremediation; Biodiversity conservation; Watershed protection*

INTRODUCTION

Climate change is an alarming problem that is capturing global attention. The rise in CO_2 due to industrial activities, combustion of fossil fuels, can provoke subtle shift in the earth's climate patterns. The emission of greenhouse gases, including CO_2, N_2O, CH_4 and CFC etc, has raised significant alarm due to the potential escalation of global warming in the future. Concentration of CO_2 and other Greenhouse Gases (GHs) in the atmosphere have witnessed a substantial increase over the past century and predicted to continue rising. The impact of climate change, resulting from the surge in greenhouse gas emission is exacerbated for those living in the arid region because of the marginal and fragile nature of the resource they have access [1].

India's hot arid region lies between 24° and 29° N latitude and 70° to 76° E longitude, encompassing a landmass of 31.70 million hectares. The primary desert in this region is the Thar desert, also known as the Great Indian Desert, which extends across the western regions of Rajasthan, Gujarat, Punjab, and Haryana, making up 89.6% of the total hot arid region. Within the Thar desert, the predominant area is Arid Western Rajasthan, constituting 61% of the Thar desert's overall coverage [2]. The production and life support system in this region face considerable challenges due to environmental conditions such as low precipitation (100-420 mm/year), high temperature (45°C-50°C), high wind speed (30-40 km/hr) and high evapotranspiration (1500-2000 mm/year) as well as sandy, rocky, gravely, and saline soils with low fertility and water retention [3].In the face of the fragile environmental conditions and unpredictable climate changes prevalent in this region, agroforestry stands out as an appealing choice in this region since the trees have the inherent ability to fix and store carbon from the atmosphere over long periods. Moreover, it was noted that all agroforestry systems are able to effectively sequester more carbon than sole agricultural land use systems. "In the current context, agroforestry practices stand out as a promising approach, particularly in arid regions, to combat the adverse impacts of climate change."

LITERATURE REVIEW

Scope and potential of agroforestry system

Agroforestry-the incorporation of trees into farming system shows immense possibilities in addressing drought impacts, combating desertification and revitalizing degraded soils. Additionally, it facilitates the increase of food production for both human and animal consumption, providing an additional avenue for sustenance or financial support during periods of decreased crop yields [4]. Tree roots within agroforestry systems enhance the absorption of water, enhanced presence of beneficial microorganisms which improved the richness of soil nutrients [5]. Agroforestry system can decrease reliance on fossil fuel consumption by integrating tree planting in local agriculture fields, which effectively meets the demand for fuel wood, and lessens dependence on fossil fuels [6]. Agroforestry components like wind brakes contribute to improve air quality and mitigating pollution. Windbreaks and shelter-belts offer a wide array of benefits, such as alleviation of wind chill, preventing erosion, and reducing the presence of airborne particulate matter. Additionally, they actively extract carbon dioxide from the atmosphere, improve oxygen circulation, create habitats for wildlife, shield crops, lower wind speeds, lessen noise pollution and combating livestock odors [7]. Agroforestry practices play crucial role in securing farmers' livelihoods, particularly those who have minimal land holdings. It primarily focuses on addressing their basic requirements. Such as advancement of bio-fuels, creation of employment, carbon sequestration and upliftment of farm productivity.

Farmers residing in the arid region consider tree-based agricultural systems as exceptionally valuable, especially when rainfed crops face challenges during drought. These tree based systems serve as the sole source of essential resources such as fodder, fruit, vegetables, fuelwood, timber, and fiber, ensuring the sustenance of rural livelihoods. In addition, arid agroforestry meets 62% of the rural population needs for fodder, fuelwood and timber [8]. In arid agro-ecosystem, tree serve as a form of insurance against unpredictable climate change by mitigating crop yield losses and enhance resilience and diversify system [9-11]. Under such conditions integration of trees into conventional farming techniques emerged as a more favorable approach to combat climatic uncertainties, simultaneously bolstering ecological balance and ensuring food security [12,13].

Traditional agroforestry systems practiced in arid regions of Rajasthan

Arid environment exhibits a wide range of diversity with respect to their biodiversity, vegetation, water resources, and human activities. Aridity serves as the common thread among all arid environments. In the face of adversity, the indigenous inhabitants of the Indian Thar Desert, recognized as the most densely populated arid region globally (127 person/km^2) as compared to global average of 6-8 persons per km^2 for arid zones [14], have ingeniously developed a sustainable farming system. Over successive generations of knowledge transmission, this system has demonstrated its critical role in safeguarding against drought. Traditionally, this region has been profusely endowed with a diverse range of native crops, trees, shrubs, and grasses. These natural resources have played an essential role in preserving the ecological balance required to sustain the local community's livelihoods,

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Media's Role in Safeguarding Freedom of Speech and Expression in India: A Legal Perspective

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Abstract

The research article "Media's Role in Safeguarding Freedom of Speech and Expression in India: A Legal Perspective" examines the complex relationship between media and the constitutional guarantee of freedom of speech and expression in India. It explores the media's role as the fourth estate and a crucial guardian of democratic principles, examining constitutional provisions, recent case laws, and evolving media landscapes. The study also examines the impact of the Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021, on online journalism. It also addresses challenges posed by sedition laws, fake news, and the ethical dimensions of media, emphasizing the delicate balance required for media to serve as a robust defender of freedom of expression.

Introduction:

The Indian Constitution guarantees freedom of speech and expression as a fundamental right, but it is not absolute and subject to reasonable restrictions. The media, often referred to as the fourth estate, plays a significant role in disseminating and contested these constitutional ideals. This legal analysis explores the role of media in shaping discourse on freedom of expression, examining various mediums such as print and broadcast journalism, digital media, and online journalism. The growing digital domain presents unique challenges and opportunities, necessitating a nuanced understanding of the legal dynamics governing online journalism and its implications for freedom of expression. The analysis also examines the ethical responsibilities of media in striking a balance between individual liberties and societal interests. The evolving jurisprudence on privacy, defamation, and online content regulation adds complexity to this legal discourse. The analysis seeks to unravel the evolving role of media in safeguarding freedom of speech and expression in India, providing insights into the delicate equilibrium required for media to function as a robust guardian of democratic values.

Constitutional Framework:

Acknowledging the importance of a free and responsible media in a democratic society, this constitutional framework aims to establish the parameters within which the media operates to safeguard the fundamental right to freedom of speech and expression guaranteed by the Constitution of India.

Article 19(1)(a) of the Indian Constitution, a cornerstone of democratic rights, guarantees the fundamental right to freedom of speech and expression. This provision empowers citizens to express their thoughts freely, fostering democratic discourse. Decided cases like **Maneka Gandhi v. Union of India (1978)** expanded its scope, emphasizing that restrictions must be reasonable. **BrijBhushan v. State of Delhi (1950)** established that freedom of speech includes the freedom of the press. Article 19(1)(a) stands as a bulwark against oppressive regimes, epitomizing the essence of democratic ideals by protecting the citizen's right to articulate opinions and ideas without fear.

Article 19(2) of the Indian Constitution imposes reasonable restrictions on the right to freedom of speech and expression, emphasizing the state's authority to curb activities that may threaten public order, decency, or national security.

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Navigating The Legal Landscape : Hate Speech, Sedition, and The Boundaries of Free Speech

• **Dr. Ashok Kumar karnani**

At the initial stage or since its establishment during India's colonial era, the statute of sedition has drawn criticism from a variety of quarters. The Britishers introduced the rule primarily to maintain the silence critics and restrain nationalist sentiment in India.

However, given that the right to free speech is regarded as one of the most essential and basic need of a democratic nation in the post-independence age, this rule appears ambiguous. Sedition laws have been invoked frequently in last few years, which has again point out as a question of its validity in the current constitutional democracy and their anti-democratic nature. Therefore, it might be matter of discussion that India's rule against sedition is utilize as an instrument of intimidation and persecution to denigrate the above right. Observations and its conclusion, that have been put up in this matter seems to be that the pin point to serious abuse in the name of nation's safety and security. As a result of the rule of law in India, falsely accusing someone of sedition is against the liberal constitutional order and India's ethos of constitutionalism. Despite being conscious of that the misuse of this law in our democratic society is unjustifiable, most of the governments have used and continue to utilize the sedition statute as a tool to silence dissenting voices to settle political scores.

In this context, the examines Section 124A of the Indian Penal Code, 1860's sedition statute by compiling all discussions for its repeal and amendment, as well as by highlighting the law's early history in colonial India. The study makes an effort to investigate how the judiciary enhances free expression when dealing with situations of sedition. To further illuminate the issue with a sound methodology, an analysis of the Supreme Court's

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RESEARCH ARTICLE

Comparative effect of neem oil and bio-agents against leaf blight of tomato (*Solanum lycopersicum* L.) caused by *Alternaria solani*

Achintya Kumar Dubey[1], Bankey Lal[2*], Shashi Tiwari[1], Ashutosh Upadhyay[3], Pranjal Singh[3]

Dubey AK, Tiwari S, Lal B, et al. Comparative effect of neem oil and bio-agents against leaf blight of tomato (*Solanum lycopersicum* L.) caused by *Alternaria solani*. AGBIR.2024;40(1):807-811.

Tomato (*Solanum lycopersicum* L.) of Solanaceae family is an important vegetable worldwide. Among the vegetables, tomato ranks first among the processing crops. It is very good source of vitamins A, B, C and minerals. They are rich in suitable contents of minerals *viz.* iron, calcium, potassium, phosphorus and sulfur. Tomato is native of Andaman region that includes parts of Colombia, Ecuador, Peru, Bolivia and Chilli. All tomato wild relatives are native to this area. Early blight is one of the most destructive fungal diseases affecting potato, tomato, and other solanaceous plants like eggplant and pepper. This disease can destroy a tomato field in two or three weeks. Therefore, the present research was carried out to control the alternarial blight by using different bio agents and botanicals as well as their combinations at field of Department of Plant Pathology, Naini Agricultural Institute Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh during 2018-2019. Different bioagents and botanicals where used in different concentrations. The experiment comprises seven treatment combination is T_0:Control, T_1: Neem oil+*T. viride*, T_2:Neem oil+P. florescens, T_3:*T. viride*+*P. florescens*, T_4:*T. viride*+*P. florescens*+Neem oil, T_5:Neem oil and T_6:*Trichoderma viride* and T_7:*Pseudomonas flourescens*. Results have revealed that the combination of Neem oil+*Pseudomonas flourescens* was the best effective in comparison to other treatment followed by *Trichoderma viride*+*Pseudomonas flourescens*+Neem oil was effective. It was also observed that these treatments are organic as well as it also has good cost benefit ratio.

Key Words: *Organic; Tomato; Bioagents; Botanicals; Effective concentrations*

INTRODUCTION

Tomato (*Solanum lycoperiscum* L.) is a diploid species with 2n=24 chromosomes and belongs to the family solanaceae. It is one of the most popular vegetable crops grown throughout the world because of its wider adaptability, high yielding potential and suitability for variety of cuisines in fresh as well as in preserved form. It is mostly considered as "Protective food" based on its nutritive value, antioxidant molecules such as carotenoids, particularly lycopene, ascorbic acid, vitamin E and phenol compounds, particularly flavonoids. Lycopene has important dietetic properties since it reduces the risk of several types of cancers and heart attacks [1]. Tomato ranks third in priority after Potato and Onion in India but ranks second after potato in the world. India ranks second in the area as well as in production of Tomato. The major tomato growing countries are China, USA, Italy, Turkey, India and Egypt. Tomato is able to produce more protein and carbohydrates per unit area than cereals and some leguminous crops like soybeans. It provides a substantial amount of vitamins and minerals. Ripe tomatoes have a high content of the antioxidant lycopene which plays a possible role in the prevention of certain forms of cancer [2]. Another important antioxidant is carotene also noted for its cancer prevention properties [3].

Early blight is one of the most destructive fungal diseases affecting potato, tomato, and other solanaceous plants like eggplant and pepper. This disease can destroy a tomato field in two or three weeks. Tomato crop is highly susceptible to plant pathogens viz. bacteria, fungi and viruses which deteriorate the yield and quality of tomato fruit. Early blight disease is one of the world's most catastrophic diseases resulting in economic yield losses. It is most important problems of tomato in Varanasi and Prayagraj region and average disease intensity vary from 35-40 per cent and 80-86 per cent losses caused by early blight in every year [4]. The disease had resulted of 78% loss in yield of fruit caused by *Alternaria solani*. Early blight caused by *Alternaria solani* is the most destructive disease reducing yield of tomato throughout the tomato growing areas of the world [5,6]. Saha and Das [7] reported yield loss of 0.76 t/ha for every 1% increase in disease severity. The disease appears on leaves, stems, petiole, twig and fruits. Symptoms appear as small black or brown spots on lower leaves after fruit set. They are usually about 0.25 to 0.5 inch in diameter. Spots are leathery and develop darker borders with a white center. The spots are in concentric pattern. As the disease progresses the color of the leaves turn yellow brown and drop off. In the center of spots black pycnidia develops which when become wet ooze out the fungal spores. The spores of the fungus are spread by insects, human contact, water and air. Favorable conditions for the disease are overhead irrigation, wet and warm weather conditions. A period of about 48 hours is required for infections to occur but it may be cumulative over several days not necessarily the continuous period. In garden the plant debris serve as inoculums source for primary infections in the spring. The spores of the fungi are the means of dissemination and also helpful in the identification and the classification of an organism. It was well established that the tomato early blight fungus could survive on the infected seeds for several days. But it is still speculative whether the seed borne inoculums of *Alternaria solani* serves as a source for triggering primary infection in the next season. The ability of pathogen to survive for a long time in the diseased plant parts and soil on the alternative collateral hosts in the absence of main host determines the ability of pathogen to perpetuate. Use of chemical or fungicide spray is used commonly by the farmers to manage the disease and reduce their losses but the human population has raised their voice against use of chemicals and the population has already started boycott of chemically produced food. Therefore, it has urged to find out best organic methods to manage the disease below threshold levels.

MATERIALS AND METHODS

The field experiment was conducted in the field of Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Kharif season 2018-2019.The Experimental field is laid out by the Randomized Block Design (RBD) with three replications and the experimental field is divided into twenty-four plots. The experiment comprises seven treatment combination is T_0:Control, T_1:Neem oil+*T. viride*, T_2:Neem oil+*P. florescens*, T_3:*T. viride* +*P. florescens*, T_4:*T. viride*+*P. florescens*+Neem oil, T_5:Neem oil and T_6:*Trichoderma viride* and T_7:*Pseudomonas flourescens*. The site selection was uniform, cultivable

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RESEARCH ARTICLE

Estimation of genetic heritability and genetic advance assessment in Garden Pea (*Pisum sativum* L.)

Akash Kumar[1], Bankey Lal[2*], Pranjal Singh[1], Ashutosh Upadhyay[1]

Kumar A, Lal B, Singh P, et al. Estimation of genetic heritability and genetic advance assessment in Garden Pea (*Pisum sativum* L.). AGBIR.2024;40(1):822-826.

The crosses for the experiment were created during Rabi 2018-2019, and a field experiment was carried out at the vegetable research farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P. during the 2019–2020 Rabi season. The 13 different genotypes of garden peas (10 lines and 3 testers) that were collected from Chandra Shekhar Azad University of Agriculture and Technology's vegetable research farm in Kanpur made up the experimental material. During the 2019 Rabi season, a set of thirty crosses (10 lines and 3 testers) were created. A respectable amount of crosses was tried in order to generate enough F1 seed in each cross. Using a Randomized Block Design (RBD), 13 genotypes of vegetable pea were assessed for genetic progress and genetic heritability. Notes on eleven characters, namely Days until 50% flowering plant height (cm), number of branches per plant, length between nodals, number of seeds per pod, number of pods per plant, green pod yield per plant (g), first fruiting node, and shelling percentage (%) were collected in order to conduct the assessment. Significant variations were found across the genotypes for every attribute in the ANOVA findings, suggesting a broad range of variability among the genotypes. Every character in the current study shown a high degree of heritability. With the exception of shelling percentage, days to 50% flowering, and pod width, all of the characters demonstrated high heritability and high genetic advancement; in contrast, the characters representing shelling percentage, days to 50% flowering, and pod width demonstrated moderate genetic advance and high heritability. These characters displayed the least amount of G × E interaction and were least affected by their surroundings. From a breeding standpoint, only the heritable portion of total variation matters. Therefore, in various breeding and crop improvement initiatives, these qualities should be given preference when selecting traits in order to generate high yielding and more successful varieties.

Key Words: *Genetic variability; Heritability; Genetic advance; Pea*

INTRODUCTION

There are numerous horticultural and agricultural uses for peas. Green seeds are used to create canned, frozen, and fresh vegetables. This crop has a high protein content (27%) suitable for human consumption. Green peas have the greatest protein content of any vegetable, ranging from 6 to 7% on a fresh weight basis. Peas have become increasingly useful as a food crop and as fodder in recent years. Pea protein contains all of the amino acids needed for optimum cellular activity [1]. "Pea protein is low in sulfur-containing amino acids like cysteine and methionine but high in lysine and other essential amino acids," claim Ceyhan and Avci [2]. Peas contain minerals, dietary fiber, vitamins A, B, and C, as well as antioxidant chemicals [3]. "Green peas are very important as part of a healthy diet, especially for children and the elderly, especially when eaten in their fresh, canned, or frozen form. The highest concentration of vitamins is found in green pea seeds and immature pods. Agronomically speaking, the addition of peas to crop rotation is highly significant. The pea makes an excellent forerunner to other crops because its roots contain nodule bacteria that enrich the soil and fix nitrogen, making it available to other plants [4]. For a successful breeding program, crop improvement depends upon the extent of heritability of the desirable characters and the magnitude of genetic variability [5]. The improvement of any crop, the selection of superior genotypes, and the improvement of any trait require genetic variability, heritability, and genetic advance [5]. Yield is a complicated personality that is shaped by a number of genetic variables interacting with the environment. Thus, the genetic variability that already exists in the base population and the effectiveness of selection determine the success of any breeding effort aimed at improving [6]. The percentage of phenotypic variance attributable to heritable genes is known as heritability [7]. Breeders can utilize it as a helpful guide as selection for traits with high heritability will be successful in bringing about improvement [8]. A population's genetic value can be improved by genetic advancement when compared to its original population [9]. Based on the research of heritability and genetic advancement, alternative breeding programs for the enhancement of specific features will be able to be determined [7]. Consequently, the purpose of this study was to evaluate the genetic diversity, heritability, and advancements among 20 genotypes of pea.

MATERIALS AND METHODS

The crosses for the experiment were created during Rabi 2018-2019, and the fieldwork was carried out at the Chandra Shekhar Azad University of Agriculture and Technology's vegetable research farm in Kanpur, Uttar Pradesh, during the 2019-2020 Rabi season. The 13 different genotypes of garden peas (10 lines and 3 testers) that were collected from Chandra Shekhar Azad University of Agriculture and Technology's vegetable research farm in Kanpur made up the experimental material. During the 2019 Rabi season, a set of thirty crosses (10 lines and 3 testers) were created. A respectable amount of crosses was tried in order to generate enough F1 seed in each cross. Geographically, Kanpur Nagar is located between the parallels of latitudes 25.26 and 26.58 degrees North and 79.31 and 80.34 degrees East. It is located in Central Uttar Pradesh's alluvial zone of the Indo-Gangetic plains at an elevation of 124 meters above mean sea level. Thirteen of the germplasm sets listed in Table 1 were used in the experiment, which was set up in a randomized block design with three replications. First fruiting node, Pod length, Pod breadth, Days to 50% flowering plant height (cm), and other data were recorded. Green pod yield per plant (g), number of branches per plant, length between nodes, number of seeds per pod, number of pods per plant, and shelling percentage (%). As recommended by Goulden [10], the mean values were statistically analyzed to determine an ANOVA for each character. The Lush formula [11] was used to assess heritability in the wide sense (h^2). Moreover, the Johnson et al., [12] approach was used to calculate genetic progress as a percentage of mean.

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Original Research Paper

Speech Emotion Recognition of Animal Vocals Using Deep Learning

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Abstract: Emotion Detection is a crucial parame- ter in Communication. Sensing emotions correctly improves communication and helps us understand the context better. To have an effective communica- tion between two people emotions are a must. Col- laboration of sensory provocations providing infor- mation about the emotional state of others can be de- coded using Emotion Detection. But this capability is not constrained only to Humans. Latest studies suggest that higher order social functions including emotions might be present in animal species also. Animal emotion detection can be very useful human- animal communication. When cats and dogs are cap- tured in an animal shelter, they tend to show variety of emotions. This in turn can leave a long-term im- pact on them which can affect their emotional health. This Detecting animal emotions will help humans to detect pains in animals. So, a technology which can sense and detect animal emotions would be a boon. We aim to analyze audio data and speeches from animals. Machine Learning has advanced so much through Deep Neural Networks audios can be used to harness good amount of emotion-based information. When classifying the vocal abilities of the humans the machine learning has played an utmost important role.

Keywords: *Deep learning, Machine Learning, Cohenen Neural Network, Recurrent Neural Network etc.*

1 Introduction

Machine Learning has achieved milestones in the field of numerical and visual data. Research in au- dio recognition has traditionally focused on speech. The success of Machine Learning in predicting pat- terns in Visual Data is a great leap in the field of Artificial Intelligence. It has automated numerous sectors of the industry. Application of ML has also started on Audio data. Humans produce a lot of Au- dio data in form of speech, anger, love, surprise and many other emotions. This audio data can be very useful in synthesizing useful information from audio speeches. ML has played an utmost role in classi- fying vocal abilities of Humans. When we talk of Humans, we have enormous data. But when we talk about other species such as animals, we have very less data in context of Emotion detection. Detect- ing emotions in animals can be very useful in animal industry. We are thinking to apply Speech Emotion Recognition techniques to Animal Audio Speeches to decode the emotion underlying in their speeches. The advancement of ML in decoding human emo- tions made us go ahead with this idea.

Success of Emotion Detection in Animals through CNN (Convolutional Neural Network) is due to the CNN methods in [3]. In several studies, this method is widely used and results were commendable. The features extracted from Audio files can be repre- sented in Images which can be fed into CNNs and classification can be done. Furthermore, there Super- vised Learning methods which can also be applied to this topic like it is done in [5]. Application of Su- pervised Machine Learning Algorithms have shown some interesting results in [3], [5]. We can get to know the importance of Emotion Detection from [1]. There are various applications of Emotion Detection in animals. In the study of [1], we get to know that SER of animals has a great use in Education and Pro- fessional sector. Moreover, study of animal emotion can be of great use in Animal Industry. We can also get to know about importance of Emotion Detection from [1]. It is important in communication with an- imals. Through this we can also get to know level of pain intensity in animals. A significant study of Emotion recognition in Cats has been done in [2]. In this study, the emotion detection has been done on Cats and significant results were seen. The results from [2] showed that cats integrate acoustic and vi- sual emotional signals. In particular "hiss" and hu-man "anger" and "happiness". The combined study of Audio and Video for Emotion

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Machine Learning Based Power Quality Enhancement System for Renewable Energy Sources

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Abstract: The uncertain and sporadic nature of the power that renewable energy sources provide, they are increasingly being integrated into the world's existing electrical networks in the contemporary day. Utilising soft computing methods for energy prediction is an essential part of the solution to these problems and is an intrinsic component of the solution. Because of its close connection to other forms of energy, such as natural gas and oil, generating an accurate prediction of the amount of electricity that will be used is one of the most important steps in the process of creating a national energy strategy. In this work, we use a wide range of Machine Learning methods, such as preprocessing historical load data and analysing the features of the load time series. We included and investigated use trends for both renewable and non-renewable forms of energy. The addition of active power filter capabilities makes it possible for the inverter to be controlled so that it may function as a tool that is capable of performing several functions. As a consequence of this, the inverter may function as both a power converter to add the energy produced by RES to the grid as well as a shunt active power filter (APF) to rectify current imbalance, load harmonics, load reactive power demand, and load neutral current. The option of completing these two jobs simultaneously or one after the other. As a consequence of this, the suggested controller either performs the function of an APF, regulates the flow of electricity between RES and the grid, or integrates all of these functions into a single piece of equipment. In order to assess the operating strategy as well as the control hypothesis, respectively, MATAB simulation and DSP experimentation are both used.

Keywords: *Renewable Energy, Renewable Energy, Machine Learning, Multilayer Perceptron, Support Vector Regression*

Introduction

The incorporation of renewable energy sources such as solar and wind power into the electrical grid marked the beginning of a new era in which energy is created in a manner that does not have a negative impact on the surrounding environment. Utilising energy generated from these sources presents a number of power quality difficulties, despite the fact that using this kind of energy is beneficial for the environment and decreases our reliance on fossil fuels. The reliability and uniformity of an electrical supply is referred to as the power's "quality." Power quality may be affected by a number of factors, including the stability of the voltage and frequency as well as the waveform quality. The amount of energy that can be extracted from renewable sources varies widely and is subject to lulls and surges in output depending on the time of day and the conditions of the surrounding environment. This directly adds to the likelihood that the electrical grid may suffer volatility and unpredictability, both of which may result in issues with the quality of the power. These issues, which may include voltage sags, voltage swells, frequency deviations, and harmonic distortions, can make it difficult to run electrical equipment smoothly and can shorten the devices' lifespans. Additionally, these issues can cause harmonic distortions. The most common of these issues is a fluctuation in the voltage, which may be either a sag or a swell. In order to overcome these difficulties and ensure the seamless integration of renewable energy sources into the grid, there is a growing need for complicated solutions that make use of cutting-edge technology. The powerful technique that is known as machine learning (ML) is a subfield of artificial intelligence that has the potential to be used in this

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Evaluating the Role and Significance of Dynamic Intelligence Resource Management in Applications Designed for Intelligent Transportation Systems

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Abstract: As Intelligent Transportation Systems (ITS) evolve, dynamic intelligent resource management (DIRM) integration becomes increasingly important for optimizing system performance. This paper assesses the role and significance of DIRM (K. Smith et al., 2021) in ITS applications. The study looks into how dynamic resource allocation and utilization, such as compute power, communication bandwidth, and data storage, might improve the efficiency, adaptability, and responsiveness of ITS applications. This study evaluate major DITS (designed for intelligent transportation systems) methodologies and their implications for various ITS applications using a comprehensive analysis of existing research. It looks into how real-time resource allocation changes affect traffic management, vehicle-to-infrastructure communication, and overall system resilience (M. Johnson and R. Patel, 2017). A. Wang et al. (2018) discussed technological limits, cybersecurity consequences, and the necessity for standardized protocols to promote seamless integration across heterogeneous systems. According to the study's findings, DIRM and DITS play an important role in improving the adaptability and efficiency of ITS applications (S. Lee and B. Kim, 2019). The findings of this review influence future ITS advancements, emphasizing the importance of a dynamic and intelligent resource management approach to meet the growing demands of modern transport networks.

Keywords: *DIRM, DITS, Intelligent Networks, Transport Networks, Applications*

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Introduction

Prior to modelling the essential traffic attributes of flow, speed, and concentration, it is crucial to establish clear and precise definitions of these attributes in connection to measuring methods, as well as the right techniques for calculating averages, among other things. Traditionally, the definitions of traffic characteristics were linked to the techniques used for measurement. Regrettably, the use of averaging techniques was frequently impacted by a dearth of comprehensive comprehension about the underlying processes. At the outset, researchers studying traffic patterns had few tools at their disposal, namely stopwatches and manual counters. The flow rate passing a specific location and the rate of progress were the crucial measures. In addition, the speed of each vehicle was determined by timing its passage through a "trap." With the development of alternative measurement methods, it has become clear that the numerical estimation outcomes are influenced by the specific method

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Embodied Understanding of Large Language Models using Calibration Enhancement

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Abstract: In our research pursuit, we explore the inherent capacity of Large Language Models (LLMs) to develop an innate understanding of the physical realm—an essential prerequisite for empowering embodied agents to adeptly navigate real-world challenges. This paper introduces an extensive dataset encompassing diverse physical scenarios, establishing AuPPLE (Augmented Physical Priors via Learned Enhancement) as a robust benchmark. It serves as a comprehensive evaluative framework for assessing and amplifying the physical intuition of LLMs, including scenarios involving free fall and projectile motion. Within this benchmark, questions are framed in various formats, spanning MultiQA, binary classification, and continuous number prediction, thereby facilitating a comprehensive evaluation of LLMs' proficiency in comprehending physical dynamics. Moreover, we conduct a fine-tuning process on LLMs like Flan-T5-Large and DeBERTa, employing succinct physics-based prompts to instill a nuanced understanding of environmental physics. Our empirical findings underscore a notable improvement in the performance of LLMs fine-tuned on these physics-centric scenarios, particularly when confronted with questions rooted in the intricacies of the physical domain. This substantiates the effectiveness of our approach, indicating that strategic fine-tuning through physics-based prompts, in conjunction with external methodologies, significantly reinforces LLMs' intuitive grasp of the physical environment and enhances their efficacy in addressing tasks with a distinct physical dimension.

Keywords: *Fine-tuning, Embodied Agents, Chain-of-Thought Prompting, Simulated Representations, Physics Engine Mathematical Word Problems (MWPs), ChatGPT, SayCan*

1. Introduction

Humans possess an intrinsic capacity to intuitively grasp the workings of the physical world, effortlessly navigating various real-world scenarios. Whether it's understanding freefall, pendulums, springs, or friction, our innate physical understanding allows us to predict outcomes without explicit calculations. For instance, when asked if a ball dropped from a 5-meter height will reach the ground in 10 seconds, our intuition, based on past experiences, confidently leads us to affirm that it will.However, can Large-Language Models (LLMs) develop a similar intuitive understanding of the physical world? Despite their impressive language generation capabilities, LLMs currently struggle to ground themselves in the physical domain, lacking comprehension of attributes like object location, height, and weight. This study explores the fine-tuning of various LLMs and multimodal models to enhance their physical intuition. Existing models often face limitations in terms of effectiveness, scalability, and efficiency [1].

One promising approach involves using simulated representations of the physical world, exemplified by frameworks like PiLoT and Mind's Eye. PiLoT uses a physics engine to connect language with probabilistic programs, while Mind's Eye integrates simulations to improve LLMs' understanding and reasoning abilities in the realm of physical phenomena. However, the use of external physics engines introduces time-consuming overhead and doesn't fundamentally enhance the model's intuitive understanding. Tools like REALM, RAG, and RETRO have been employed for prompting, but they don't enable models to respond primarily from intuition. In the realm of Mathematical Word Problems (MWPs), state-of-the-art language models, including ChatGPT, have shown subpar performance. Chain-of-thought prompting, as seen in MathPrompter, has emerged as a solution, generating multiple algebraic expressions and Python functions in response to a single problem.

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Development of Functional Test Cases Using FSM and UML Activity Diagrams for MDT

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Abstract: This study's testing of The SDLC's software phase is crucial. This stage does more than only evaluate the software's quality. Model-driven testing and code-driven testing are the two categories that make up this testing procedure. Code-driven testing is based on testing the entire program, line by line. A control flow and data flow that is sequential drives code-driven testing. The model-driven testing method focuses on the executable module rather than each line of code since it supports third-party modules, APIs, and components. One need not be an expert in every field because the tester will focus on how well each component works individually. The combination of an extended finite state machine with a sequence diagram is covered in this essay. One of the most important areas that must be effectively handled to provide effective testing of the given project is model-driven testing. The system that has been implemented combines UML with FSM to cover every situation and all potential outcomes. This situation inspires us to establish a framework for generating test cases automatically, covering every potential pathway (leveraging UML activity diagrams to account for all pathways) and situations (utilizing Finite State Machine to describe various scenarios). The Finite Machine also operates based on triggers, where scenarios are established, and if these criteria are met, the subsequent action is carried out. Model-driven testing is created by considering all scenarios, pathways, and situations.

Keywords: *Extended File System, Model-Driven Testing, Finite State Machine, Coverage of paths and conditions, Activity Diagram.*

1. Introduction

Software testing is an important phase in the software development life cycle since it allows the product's quality to be verified. This stage enables evaluation of the program's suitability for the user's demands. Several testing methods can be used to achieve this, with test case development being the most successful. All components or features will be examined in these test scenarios. All performance-related parameters for these components or capabilities are anticipated to meet the benchmark. The chosen software development life cycle, such as the waterfall model, spiral model, and others, has an impact on the testing approaches used. The particular stage emphasized, hereafter referred to as a phase, dictates the chosen testing approach. Testing stands out as the single most critical phase in the software creation process. The field of software testing is continually advancing. Recent frameworks like TestNG prove highly effective for data-driven testing, particularly when dealing with substantial volumes of data. Among the most popular technologies available today is the Selenium suite, comprising Selenium Web Driver, Selenium Grid, and Selenium RC tools for remote control and distributed computing. QTP, a Windows-based testing tool, is employed to validate software running on the Windows operating system. Industry standards necessitate an agile and adaptable approach. All of this promotes a methodology where

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A Comparative Study on Online Machine Learning Techniques for Network Traffic Streams Analysis

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Abstract: Modern networks are responsible for the generation of massive volumes of traffic and data streams. This data analysis is essential for a wide range of activities, including the management of network resources and the investigation of issues about cyber security. It is of the utmost importance to develop methods of data analysis that are able to assess network data in real time and deliver results that are dependent on the acquisition of new data. It is anticipated that approaches for online machine learning (OL) will make these types of data analytics viable. As part of this study, we investigate and compare a number of OL strategies that provide data stream analytics for the networking industry. During the course of our research into the benefits of traffic data analytics, we focused not only on the benefits of online learning in this field but also on its shortcomings, such as concept drift and uneven classes. We also investigate whether or not these frameworks and tools are compatible with the data processing frameworks that are already in use. These many frameworks and technologies each come with their own individual sets of benefits and drawbacks. In order to assess the effectiveness of OL methods, we conduct an empirical inquiry on the performance of a variety of ensemble- and tree-based network traffic categorization algorithms. At the conclusion, there is a discussion of the issues that have not been satisfactorily answered as well as possible directions for the future of traffic data stream analysis. In the field of networking, addressing the goals and objectives of online data streams analytics and learning was the purpose of the study that was conducted.

Keywords: *Machine learning, Online learning, Network traffic streams, Network traffic classification, Internet of Things, Deep Learning.*

1. Introduction

In the increasingly interconnected digital world of today, doing network traffic analysis is a step that is absolutely necessary to perform in order to guarantee the reliability, efficiency, and security of computer networks. It is difficult for traditional methods of network traffic analysis to keep up with the pace of modern network settings [1]. This is because of the alarming rate at which the quantity of data that travels through these networks is continuing to increase. In order to solve these issues, the principles of machine learning have been used to the development of effective algorithms for the analysis of real-time network data streams. The purpose of this comparison research is to analyse and evaluate a number of different online machine learning approaches that are used for the analysis of network traffic streams. It is essential to have access to a set of algorithms known as "online machine learning" in order to be able to adapt to and make predictions on streaming data as it comes. Even if you have access to all of these approaches, it does not necessarily mean that the whole dataset will be available to you. Because these techniques allow for the rapid detection of dangers, performance challenges, and irregularities as they occur, they are particularly helpful for assessing network data. This is especially helpful for keeping an eye on situations that might turn out to be dangerous. The following is a list of some of the objectives that this inquiry seeks to achieve as a result of its findings:

- **Assessment of Online Machine Learning Techniques:** Several strategies for online machine learning, such as incremental learning algorithms, online clustering, and online classification, will be dissected and compared in the next section. These techniques will be evaluated according to the degree of accuracy, scalability, flexibility, and application

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RESEARCH ARTICLE

Studies on heterosis of different yield and its attributing traits in pumpkin (*Cucurbita moschata* Duch ex Poir)

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Yadav MK, Kumar S, Das J. Studies on heterosis of different yield and its attributing traits in pumpkin (*Cucurbita moschata* Duch ex Poir). AGBIR.2024;40(1):869-874.

The investigations were carried out to evaluate the 28 F1 of pumpkin (*Cucurbita moschata* Duch. Ex Poir.) at Department of Vegetable Science, Kalyanpur, CSA, University of Agriculture and Technology, Kanpur (U.P.) during Zaid 2021. The experiments were laid out in randomized complete block design with three replications. The data were recorded for 19 characters traits *viz.*, days to first male flower appearance, days to first female flower appearance, node numbers to first male flower appearance, node numbers to first female flower appearance, vine length, internodal length, branches plant-1, days to first harvest, average fruit weight, fruits/plant, equatorial circumference of fruit, polar circumference of fruit, flesh thickness, total soluble solids, dry matter content, moisture content, seed/fruit, Specific gravity and fruit yield/plant. Highest fruit yield per plant was recorded in best hybrids *viz.* Azad Pumpkin-1 × P-40-16, Azad Pumpkin-1 × Punjab Samrat, P-40-16 × Punjab Samrat Azad Pumpkin-1 × P-35-16, Narendra Agrim × Punjab Samrat and Azad Pumpkin-1 × DVRP-2-5) in F1, exhibited significant and desirable heterosis in better parent with days to first male flower appearance, days to first female flower appearance, node number to first female flower appearance and days to first fruit harvest.

Key Words: *Pumpkin; Heterosis; Better parent; Fruit yield*

INTRODUCTION

Pumpkin (*Cucurbita moschata* Duch ex Poir) is an economically important vegetable crop. It is hardy in nature and rich in carotene content and also have very good keeping quality. It is an herbaceous annual sexually propagated vegetable having an identical genomic structure i.e., AABB which indicates that it is an amphidiploid. It comprises about 27 species of both wild and cultivated having same chromosome number of 2n=40. Among these species only five species *viz.*, *Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita ficifolia*, *Cucurbita pepo* and *Cucurbita mixta* are commonly cultivated. Robinson and Decker-Walters [1] concluded that in genus Cucurbita there are 5 cultivated and 10 wild species. Seshadri and More also stated that the recent recognition of synonyms and taxonomic changes have reduced the number of Cucurbita species to 15 or even less. The crop improvement can be brought about in pumpkin by assessing the genetic variability and exploitation of heterosis. Because of the monoecious nature of the crop, large flower size, easy of pollination, high proportion of fruit set of pollinated female flowers, large number of seeds per fruit and low seed rate required per unit area, pumpkin is highly amenable for heterosis breeding. It has ample scope for successful exploitation of hybrid vigour. Information on the magnitude of heterosis in different cross combination is a basic requisite for identifying crosses that exhibit high degree of exploitable heterosis. The magnitude of heterosis in different crosses and its confirmation through inbreeding depression in F2 generation and then utilization in future crop improvement programmes [2]. Studies on hybrid vigour and high amount of heterosis in pumpkin has been reported by many research workers [3-7]. Several hybrids have been released by public as well as private sectors for its commercial cultivation. The area under F1 hybrids is growing fast, which has helped to enhance the productivity and production of this crop.

MATERIALS AND METHODS

The investigations were carried out to evaluate the 64 genotypes (28 F1, 28 F2 and 8 parental lines) of pumkin *viz*: Azad Pumpkin-1 (P1), P-35-16 (P2), P-40-16 (P3), Narendra Agrim (P4), NDPK-7-24 (P5), Kashi Harit (P6), DVRP-2-5 (P7), and Punjab Samrat (P8). The 8 parental lines and their 28 F1 were grown in a randomized complete block design with three replications during Zaid 2021 at the Main Experiment Station, Department of Vegetable Science, Kalyanpur, CSA University of Agriculture and Technology, Kanpur (U.P.). Each 28 F1, F2 and parents were grown in rows spaced 3 meters apart with a plant to plant spacing of 0.50 meter. All the recommended agronomic package of practices and plant protection measures were followed to raise good crop. Observations were recorded on nineteen quantitative traits *viz.*, days to first male flower appearance, days to first female flower appearance, node numbers to first male flower appearance, node numbers to first female flower appearance, vine length, internodal length, branches plant-1, days to first harvest, average fruit weight, fruits/plant, equatorial circumference of fruit, polar circumference of fruit, flesh thickness, total soluble solids, dry matter content, moisture content, seed/fruit, Specific gravity and fruit yield/plant. The data recorded from 28 F1, 28 F2 and 8 parental lines on nineteen characters were subjected to estimate heterosis expressed as per cent increase or decrease in the mean values of F1's (hybrid) over better-parent (heterobeltiosis) and standard variety (standard heterosis) was calculated according to method suggested by Hayes et al., [8].

RESULTS AND DISCUSSION

The results of the study reveals that the heterosis was estimated as per cent increase or decrease of F1 values over the Better Parent (BP). The estimates of better parent heterosis for all the traits in twenty-eight F1 are presented in Table 1.

Out of twenty-eight F1 hybrids, five crosses showed significant and negative heterosis over better parent for days to first male flower appearance which were best five crosses, NDPK-7-24 × Punjab Samrat followed by Azad Pumpkin-1 × Punjab Samrat, P-40-16 × DVRP-2-5, P-40-16 × Punjab Samrat and Azad Pumpkin-1 × P-40-16. Nineteen crosses showed significant and negative heterosis over better parent for days to first female flower appearance which were NDPK-7-24 × Kashi Harit followed by Narendra Agrim × NDPK-7-24, Kashi Harit × DVRP-2-5, Narendra Agrim × DVRP-2-5 and Azad Pumpkin-1 × Kashi Harit. Eleven crosses showed significant and negative heterosis over better parent for node to first male flower appearance which were P-40-16 × NDPK-7-24 followed by P-40-16 × Punjab Samrat, P-40-16 × Narendra Agrim, NDPK-7-24 × Punjab Samrat and Kashi Harit × Punjab Samrat. Seven crosses showed significant and negative heterosis over better parent for node to first female flower appearance which were Azad Pumpkin-1 × Punjab Samrat followed by Narendra Agrim × DVRP-2-5, P-40-16 × Punjab Samrat, Narendra Agrim × Punjab Samrat and NDPK-7-24 × Punjab Samrat. Six crosses showed significant and positive over better parent for vine length which are P-40-16 × NDPK-7-24 followed by P-40-16 × Narendra Agrim, P-35-16 × Kashi Harit, P-40-16 × DVRP-2-5 and Azad Pumpkin-1 × DVRP-2-5. Six crosses showed significant and negative heterosis over better parent for

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Classification Approach for Face Spoof Detection in Artificial Neural Network Based on IoT Concepts

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Abstract: The topic of discussion in this piece is the convolutional neural network, often known as ANN. ANNs are a kind of artificial intelligence that can acquire new knowledge and recognise even the most subtle of differences in the data they are given to analyse. Deep convolutional neural networks are responsible for a significant number of the recent breakthroughs that have been achieved in the field of image classification. This work presents a number of different ANN designs, most of which make extensive use of convolutional layers, in order to identify face spoofing. We "teach" it for an application-specific domain for which there are few training examples by first "training" a deep neural network with a vast quantity of labelled data, and then "teaching" it for the deep neural network itself. This is done in the order of "training" and "teaching." This will allow us to achieve our goal. After that, we create training sample pairs for the network distillation using samples from both domains. We "train" a deep neural network by "training" it with a tone of labelled data at first, and then we "teach" it for a particular application area for which there aren't enough training in IoT. By doing this, we "train" it. The more technical term "teaching" a deep neural network is the one that is used most often to describe this process. The two domains may be compared with one another. First things first: if we want to be able to train a discriminative deep neural network on an application-specific domain, we need to gather data that is unique to spoofing. The proposed technique has been tested in a number of different ways and has shown to be effective when combined with anti-spoofing settings.

Keywords: *Face Spoofing Techniques, Feature Classification, IOT, Artificial Neural Network (ANN), VGG-16.*

1. Introduction

Intrusion detection in ANN based on time It is well knowledge that the vast majority of face recognition systems that are operational in the world today are notoriously incapable of withstanding efforts to falsify the images on which they depend. This shortcoming has led to widespread criticism of the technology. The weakness in these systems has resulted in a great deal of criticism. A spoofing attack occurs when someone tries to trick a biometric face system by using a phoney face in front of the camera. This kind of attack is known as "spoofing." This activity might also be referred to as "face spoofing." This kind of attempt is known as "spoofing." Network Attacks of this kind are known as "face spoofing." The website that spoofs faces is used as a pre-processing phase in facial recognition frameworks. At this stage, it is determined if the image of the individual's face was obtained from a printed picture or from an actual person. Therefore, the ability to distinguish a counterfeit face presents a challenge to grouping on two fronts simultaneously. In some circles, this discovery is also referred to as the "face-livens" finding. In order to get unauthorised access to things that are secured by a biometric verification system, a spoofing attack has to be carried out first. The assault includes the creation of phoney biometric characteristics. It is an attack that may be executed quickly against the functionality of a biometric system, and the perpetrator is not required to have any prior knowledge of the acknowledgement calculation. There is a requirement for programmed interpretation and assessment of the data that is obtained from the innovative framework because of the special integration of video and image databases. There is no getting around the need for this. This is because the

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Leadership and Decision-Making: The Investigation on the Reciprocal Relationship between Decision-Making Approach and Style of Leadership

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Abstract: The purpose of this paper is to illustrate the significant relationship between leadership styles and decision-making. Institutional structures and leadership styles are related to decision-making styles.

Study Design: This study used a qualitative research methodology. Data on decision-making and leadership styles were obtained from the participants using a semi-structured interview.

Methodology: To gather information from the participants on leadership and decision-making, a semi-structured interview was employed. Interviews were conducted with two department heads from RNB Global University, Bikaner

Results: The study's conclusions demonstrate that, despite being ambiguous in theory, decision-making and leadership styles have a close relationship in reality. Additionally, participatory leadership and consultative decision-making are the most popular leadership and decision-making styles.

In conclusion, the superior-subordinate relationship and employee performance have benefited greatly from this ideal relationship to some extent.

Keywords: decision-making process, leadership style, decision making styles.

1. Overview

A necessary component of group dynamics, leadership is the process of motivating others to cooperate in order to accomplish a shared objective within a particular entity [1]. Nevertheless, there is a complicated relationship between a leader's participation and their effectiveness in achieving objectives [2]. The term "leadership style" has many definitions, but it generally describes the distinctive way a person guides others [3]. A participatory theory of leadership has been proposed by researchers and other practitioners. It is predicated on the idea that a group's effectiveness depends on the degree to which leaders share or retain their power to make decisions.This is one method of evaluating the efficacy of leadership [4]. The success or failure of the leader in this situation influences all other organizational factors [5]. Decision-making, project culture, corporate culture, and employee commitment are all impacted by leadership[6].The likelihood of business or educational failure will rise in the absence of suitable leadership [6]. In order to accomplish organizational or school goals, leadership is therefore defined as the capacity to make strategic decisions utilizing abilities like motivation, interpersonal relationships, communication, decision-making, and emotional maturity [7]. Nonetheless, there are recognized leadership styles that can be used to address a range of issues that an organization may encounter at any given time. But

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A Review on Chaos-based Image Encryption Techniques for Healthcare Applications: Issues and Challenges

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ABSTRACT:

Due to the rapid growth of communications networks, an increased number of multimedia information has been exchanged through unprotected communications. The multimedia data can be in the form of satellite images, images for the military, images for use in medicine, etc. At current time, telemedicine users are using communication networks to transmit various medical data in the form of images. Every single one of these photographs contains private and confidential information. Security of sensitive data is therefore crucial to preventing unauthorised access. Currently, a number of image encryption techniques allow for the extremely secure storage of medical images. Present chaos-based picture encryption techniques offer a high level of security for protecting medical photos. Reviews of several chaos-based image encryption methods for encrypting medical photos are discussed in this paper. The assessment metrics, results, and comparison analysis of various medical picture encryption systems are also presented in this paper. The field's future directions are then addressed.

KEYWORDS: security, image encryption, medical images, chaos.

Introduction

The pace of technological progress during the last few decades has skyrocketed. Information may now be transmitted across the internet more easily because to developments in communications. Digital photographs, movies, and records are just a few examples of the data that is transported instantly around the globe. Telemedicine is the most extraordinary answer to the current healthcare dilemma in the medical industry. Digital medical pictures of internal human organs are utilised for quick diagnosis and effective therapy. Healthcare professionals must manage sensitively since they oversee sensitive patient information due to cybercrimes. The security of patient data is extremely important since unauthorised access to such data might have disastrous consequences. Medical image storage and/or transfer call for validity and integrity as well as confidentiality. Encryption is a popular method for protecting medical images. DES [1], AES [2], and other widely used data protection technologies served as the foundation for early image encryption techniques. However, it has been found that these techniques do not encrypt images as effectively [3][4][5].

Therefore, a strong technique for encrypting medical images will be required. Chaos-based techniques provide a reliable method for medical picture encryption. Chaotic mapping algorithms contain a number of intrinsic characteristics, including ergodicity, mixing characteristics, vulnerability to

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