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1. AGROMETEOROLOGY

Role Agrometeorological Services in Climate-Smart Agriculture

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India is agrarian country, agriculture and associated sectors provide income to about 70% of the Indian population and major contributor to the Gross Domestic Product (GDP). The answer to growing demand of food for increasing population lies in the increase of production and productivity per unit area and per unit time.Variables like genetic potential of crop cultivar, soil and weather plays a significant role in determining growth and production which vary significantly across time and space. Increase in crop area is very difficult due to unavailability of the land for agriculture purpose. Aside from the constraints associated with the agricultural productions we are confined with the other constraints like of climate change, occurrence of extreme events, global warming, unpredictable seasonality. Considering all the constraint, one of the possiblesolutions to meet the increasing need of food through increasing productivity as well as using climate smart agriculture.

Climate-smart agriculture, is an integrated approach to managing the ladscape to help adapt agricultural methods, livestock and crops to the ongoing human induced climate change ,wherever possible. It has three main objectives: (1) sustainably increasing agricultural productivity and incomes; (2) adapting and building resilience to climate change; (3) reducing and/or removing greenhouse gas emissions to effectively support development and ensure food security in a changing climate., wherever possible.

All the activities of agriculture, from pre-sowing to post-harvest are affected by the weather. Weather parameter like rainfall, temperature plays a significant role in determining crop production. From pest infestation to disease infection are highly influenced by the change in weather parameters. As such, the behavior of weather has a significant influence on our country's economy. If the weather could be predicted sufficiently in advance, the farmer can take corrective measures to minimize the losses in agricultural productions; Sustainably increase in agricultural productivity and income and resilience to climate change can be achieved.

Despite considerable advancement in technologies and improved irrigation facilities. Indian farmers are still dependent on seasonal rains which are highly variable both in time and space. Extreme weather events such as drought, floods, cold and heat waves, hails, squalls, tropical storms severely affect the production. Their malevolent effect may be partially reduced if the occurrence of the event is predicted in advance and farmers are suitably advise to take ameliorative measures. Thus, the weather forecast assumes considerable importance for agricultural activities. For the purpose of effective planning of varieties of seeds, need-based application of fertilizer, pesticides, insecticides, efficient irrigation and harvest planning. Weather forecast with extended time are necessary. Remote sensing has shown a high potential to provide valuable information regarding the extent and management of agricultural land various spatial and temporal scales.

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In the past few years, a large number of space-borne sensors have developed. In particular, new sensors, such as synthetic aperture radar (SAR) and passive microwave, have extended Earth observation capacity. Application on satellite-based product provide good opportunity in decision making.It has enabled the regular and timely monitoring of crop health condition, crop growth and development, and the effect of climate variability and changes on crop growth and development at regional and local scale which are vital for economic and environmental purposes.

Development in such atechnology has avail implementation of services, like agrometeorological advisory, which relate the past, current and forecasted weather to agricultural operations. It includes location specific range weather forecast for rainfall, cloud cover, average wind speed, predominant wind direction, and maximum and minimum temperature trends. These are communicated to the units in real-time using fast communication facilities like Information and communications technologies (ICTs), including the INTERNET. Figure 1 shows the data assimilation and Forecast System for preparation of Agro-meteorological advisory. Later on, with a panel of experts in various subject matters of agriculture and disseminates the same to the farmers through different mass media like newspaper, radio,

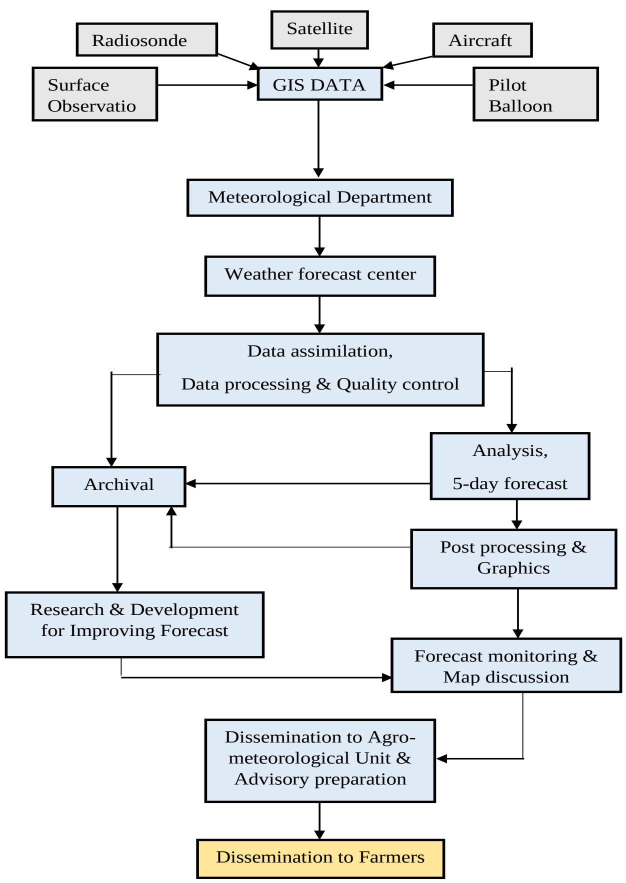


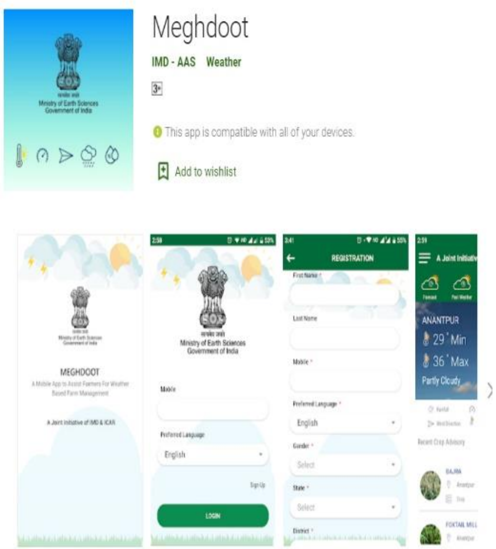
Fig. 1 Forecast System for preparation of Advisory

television, personal contacts.

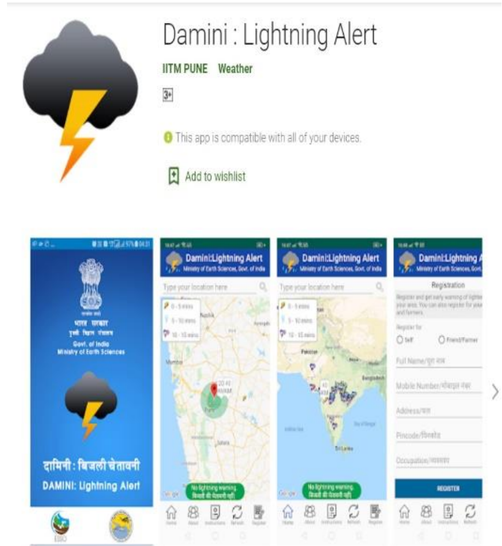
Advisory are prepared considering information like of major soil types, major crops, pest and disease, weather. It provides weather sensitive package of practices, soil characteristic, crop information, phenological information, pest and disease, climate data, adverse weather conditions. Timely and accurate agrometeorological forecast and advisory has proven to be effective tools for crop production.

Initiative taken in terms Information and Communication for agrmeteorology in India:

Meghdoot Mobile Application:



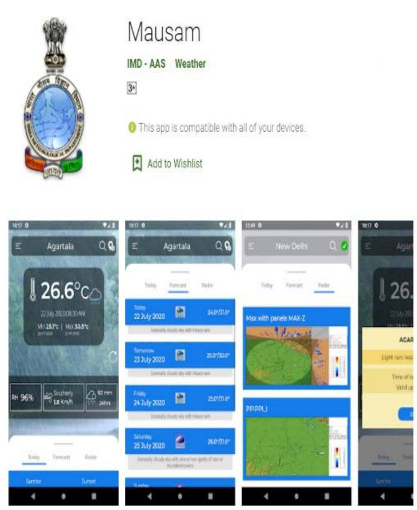
Meghdoot is a joint initiative of the Indian Meteorological Department (IMD) and Indian Council for Agriculture Research (ICAR) to bring high resolution weather forecast based agro advisories to farmers in vernacular. The Agro-Met Field Units (AMFU) issue contextualized district and crop wise advisories every Tuesday and Friday. The Meghdoot App allows farmer and interested user to access these advisories in a user-friendly manner. The advisories are also issued in vernacular wherever available. Apart from the crop advisory, the app also makes available observed weather and weather forecast.



Damini Mobile Application:

Damini Lighting app is developed by Indian Institute of Tropical Meteorology (IITM)-Pune and Earth System Science Organization (ESSO). This application monitors all lighting activity which are happening in specifically for all India, and alerts through notification when lighting is happening near by you with the help GPS, under 20km and 40km. Details description of instruction, precautions are provided in application. Does and Don't for in Specific situation and when in lighting prone area.

Mausam Mobile Application:



MAUSAM is a Mobile application of the India Meteorological Department (IMD), Ministry of Earth Science (MoES), Government of India to provide seamless and user-friendly access to weather products available on https://mausam.imd.gov.in/. users can access observed weather, forecast, radar images and be proactively warned of impending weather events. The app's development and deployment are being led jointly ICRISAT's Digital Agriculture & Youth (DAY) team and Indian Institute of Tropical Meteorology (IITM) under the Monsoon Mission program of MoES.

Evolution and Natural selection being basic human traits, Development of new technologies and its adaptation will help humankind in ongoing need of food for overgrowing world population, emission of green house gases leading to global warming and so, Climate change, other than it's being problem itself it affects agriculture directly, demanding sustainable agriculture. Weather parametersplaying pivotal role in agricultural production, Giant forward leap in the vision of Climate-Smart Agriculture can be made implementing Services of Agricultural-meteorology.

Considering present condition, the role of weather and climate in development of a Climate Smart agriculture and sustainable agricultural production system must be recognized by one and all. Additional research should be encouraged to enhance the use of climatology for agroclimatic zones must be given highest priority. Improved technology must be implemented in data collection, networking and for study of crop weather relationship.

2. AGRICULTURE

Vertical Farming: The Next Big Thing

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Introduction

Vertical farming, involves growing crops in controlled indoor environments, with precise light, nutrients and temperatures. In vertical farming, growing plants are stacked in layers that may reach several stories tall. It enables farmers to achieve constant production of plants – all year round without seasonal, regional or climatic influences. Controlled environment agriculture, more commonly known as Vertical Farming - the process of growing food or other agricultural products within factory style situations, without the typical natural resources associated with plant production, such as soil and sunlight.

High – tech indoor farming methods

Vertical farms come in different shapes and sizes, from simple two-level or wall-mounted systems to large warehouses several stories tall. But all vertical farms use one of three soil-free systems for providing nutrients to plants - Hydroponic, Aeroponic and Aquaponics.

Hydroponics

The predominant growing system used in vertical farms, hydroponics involves growing plants in nutrient solutions that are free of soil. The plant roots are sub- merged in the nutrient solution, which is frequently monitored and circulated to ensure that the correct chemical composition is maintained.

Advantages of hydroponics farming

- Higher yield, 20 times more production than traditional farming
- Only 10% water required
- Produce more with less space and lest time
- No soil is required
- Off season production 100% whole year cultivation
- Plants grow faster and healthier

Aeroponics

The National Aeronautical and Space Administration (NASA), in the 1990s, interested in finding efficient ways to grow plants in space and coined the term "aeroponics," defined as "growing plants in an air/mist environment with no soil and very little water." Aeroponics systems are still an anomaly in the vertical farming world, but they are attracting significant interest. An aeroponic system is by far the most efficient plant-growing system for vertical farms, using up to 90% less water than even the most efficient hydroponic systems. Plants grown in these aeroponic systems have also been shown to uptake more minerals and vitamins, making the plants healthier and potentially more nutritious.

Aquaponics

An Aquaponics system takes the hydroponic system one step further, combining plants and fish in the same ecosystem. Fish are grown in indoor ponds, producing nutrient-rich waste that is used as a feed source for the plants in the vertical farm. The plants, in turn, filter and purify the wastewater, which is recycled to the fish ponds.

Advantages of vertical farming

- Lower cost base due to protection from floods, droughts and sun damage.
- No requirements for fertilizers, herbicides, or pesticides, soil, long-distance transportation, farm machinery such as tractors, trucks, or harvesters.
- No seasonality issues because continuous crop production occurs all-year round.

Disadvantages

- High electricity usage to run lighting and heating/ cooling in a vertical farm impacts the economics.
- Quite expensive.
- The current model for crops grown in vertical farms focuses on high-value, rapid-growing, small-footprint and quick-turnover crops, such as lettuce, basil, and other salad items.

Challenges of vertical farming

- Monitoring of Optimum Air Quality, Temperature and Relative Humidity, Water Quality , Light Quality, Nutrients Concentration and pH in Nutrient Solution
- Substrate of Vertical Eco-Farming
- Design of Watering Systems
- Selection of Ideal Crop for Vertical Eco-Farming
- Vulnerability of Vertical Eco-farming

SWOT Analysis of Vertical Farming

Strength

1. Faster and high yields
2. Grows healthier crops
3. No pesticides needed
4. Savings in water
5. Reuse of nutrient solution
6. Can grow round the year
7. Requires less land surface

Weakness

1. High initial costs
2. Requires precision monitoring
3. Limited to low profile crop
4. Requires high energy

Opportunities

1. Highly controlled environment
2. Artificial lights may be used
3. No seasonal restrictions
4. Crop need based nutrient

Threats

1. Failure to the any system components of the vertical irrigation system may leads to rapid plant death

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3. PLANT BIOTECHNOLOGY

Biofortification for Improved Crop Nutrition

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Summary

Micronutrient malnutrition, or "hidden hunger," affecting over two billion people globally, is a pressing global health concern. This article delves into the concept of biofortification as a promising strategy to combat hidden hunger by enhancing the nutritional content of staple crops. Hidden hunger disproportionately impacts vulnerable populations, leading to serious health complications. Biofortification, achieved through conventional breeding, agronomic practices, and biotechnology, presents a sustainable and cost-effective solution. Successful examples include vitamin A-rich orange-fleshed sweet potatoes, iron-fortified beans, and zinc-biofortified rice. While biofortification holds immense potential, challenges such as consumer acceptance, nutrient retention, and regulatory frameworks must be addressed. The future of biofortification involves expanding the range of biofortified crops, combining different approaches, and fostering collaborations between researchers, farmers, policymakers, and consumers. In conclusion, biofortification stands as a transformative strategy to alleviate hidden hunger, offering a pathway to a healthier and more nourished future.

Introduction:

Micronutrient malnutrition, also known as "hidden hunger," affects billions of people globally. This condition arises from a deficiency in essential vitamins and minerals, even when calorie intake might be sufficient. Biofortification emerges as a promising strategy to address this challenge by enhancing the nutritional content of staple food crops. This article explores the concept of biofortification, its various methods, and its potential to improve public health and dietary needs.

The Burden of Hidden Hunger

Micronutrient deficiencies, particularly in iron, vitamin A, zinc, and iodine, affect over two billion people worldwide [1]. These deficiencies are prevalent in developing countries, where diets often rely heavily on staple crops like rice, wheat, and maize. While these crops provide energy, they are often deficient in essential micronutrients. Children, pregnant women, and lactating mothers are particularly vulnerable to hidden hunger, leading to health complications like stunted growth, impaired cognitive development, increased risk of infections, and even maternal mortality [2].

Biofortification: A Powerful Tool

Biofortification is a science-driven approach to increase the density of essential vitamins and minerals in food crops. Unlike food fortification, which adds nutrients to processed foods after harvest, biofortification addresses the issue at the source, during plant growth. This strategy offers several advantages:

- **Sustainability:** Biofortified crops are self-sustaining. Once farmers adopt these seeds, they can continue planting and consuming them without relying on external interventions.
- **Cost-Effectiveness:** Biofortification is a relatively inexpensive approach to improve public health outcomes compared to individual micronutrient supplementation programs.
- **Accessibility:** Biofortification targets staple crops, reaching populations who rely heavily on them for sustenance.

Methods of Biofortification

Biofortification can be achieved through three main approaches:

- **Conventional Plant Breeding:** This method leverages natural genetic variations within crop species to develop varieties with higher levels of micronutrients. Plant breeders identify and select plants with desirable traits and use them to create new generations with enhanced nutritional content.
- **Agronomic Practices:** This approach focuses on optimizing soil conditions and nutrient management practices to increase the availability and uptake of micronutrients by crops. It involves applying mineral fertilizers enriched with specific micronutrients or utilizing organic matter that promotes their absorption.
- **Biotechnology:** This method utilizes genetic engineering techniques to introduce genes from other species that control the production and storage of micronutrients in crops. This approach is still under development but holds promise for creating biofortified crops with even higher nutrient levels.

Examples of Biofortified Crops

Biofortification efforts have already yielded significant results. Here are some successful examples:

- **Vitamin A-Rich Orange-Fleshed Sweet Potato:** This biofortified sweet potato variety contains high levels of beta-carotene, which the body converts

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into vitamin A. This innovation has significantly reduced vitamin A deficiency in children in several African countries.

- **Iron-Fortified Beans:** Biofortification research has developed bean varieties with increased iron content, addressing iron deficiency, a major public health concern globally.
- **Zinc Biofortified Rice:** Zinc deficiency is another widespread micronutrient deficiency. Biofortified rice varieties with higher zinc content are being developed and evaluated for their potential to improve public health.

Challenges and Considerations

While biofortification offers a powerful tool for addressing hidden hunger, there are still challenges to overcome:

- **Consumer Acceptance:** Ensuring that biofortified crops have desirable taste, texture, and cooking characteristics is crucial for their adoption by farmers and consumers.
- **Maintaining Nutrient Levels:** Biofortified crops need to be bred to retain their enhanced nutrient content throughout the food chain, from harvest to storage to consumption.
- **Regulatory Frameworks:** Establishing clear regulations and policies for the development, testing, and deployment of biofortified crops is essential.

The Future of Biofortification

Biofortification holds immense potential to improve global nutrition and public health. Continued research and development efforts are crucial to address existing challenges and explore new possibilities. This includes:

- Developing biofortified varieties for a wider range of crops.
- Combining different biofortification approaches for even greater impact.
- Enhancing partnerships between researchers, farmers, policymakers, and consumers.

Conclusion

Biofortification offers a sustainable, cost-effective, and accessible strategy to combat hidden hunger. By harnessing the power of science and agriculture, biofortification can empower communities to cultivate and consume crops rich in essential micronutrients, paving the way for a healthier and more nourished future.

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FAO/WHO.

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4. AGRICULTURE

Patent and its Application in agriculture

Sushmitha U S[1], M. R. Prajapati[2], Ritik Digamber Bisane[1]

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Introduction

Intellectual property encompasses the products of human creativity, such as inventions, literature, artistic works, symbols, names, and images, which have the potential to result in practical applications or products.

Intellectual property rights (IPR) are the legal rights granted to creators or inventors, providing them with exclusive control over the use and distribution of their creations for a defined period. These rights enable creators to derive economic benefits from their creations.

The primary forms of intellectual property rights protection include patents, trademarks, trade secrets, copyrights, designs, integrated circuits, plant breeder's rights (PBR), and geographical indications.

A patent is a form of intellectual property right granted by a government to an inventor, giving them exclusive rights to prevent others from making, using, or selling the invention for commercial purposes for a specified period. The term "patent" originates from the **Latin** word "**patere**" meaning to "**lay open**" or make available for public inspection.

Fundamentals of patents

- Exclusive monopoly rights conferred by the government
- The national-wide right to exclude others from making, using, selling, offering for sale or importing a patented invention
- Valid for 20 years from the date of filing
- No rights to unclaimed subject matter
- It is a Territorial right

A brief history of Indian patent system

1856: 'The Act of Protection of Inventions' based on the British Patent Law of 1852;

1859 The act modified as 'Act of Patent Monopolies' called exclusive privileages (making, selling, and using inventions in India and authoring to do so for 14 years from the date of filing specification)

1. 1872 The Patterns and Designs Protection Act
2. 1883 The Protection of Inventions Act
3.
4. 1888 Consolidated as the Inventions and Designs Act
5. 1911 The Indian Patents and Designs Act
6. 1970 The Indian Patents Act
7. 1999 Amendment
8. 2002 Amendment
9. 2005Amendment

India became a member of the World Trade Organization on January 1, 1995 As a result, need to comply with TRIPS Agreement.

The importance of patents

1. An important source of scientific and technical literature
2. Avoids duplication
3. Identifies emerging technologies and emerging areas
4. Encourage industrial development
5. Encourage complete disclosure of invention
6. Focus on commercial relevance of the invention
7. Prevent exploitation of researchers by giving them recognition as inventor and providing them royalty when their inventions get commercialized
8. Generate revenue when invention get commercialized

Basic criteria for patentability

The three basic criteria that any invention must meet in order to deserve a patent are:

- **Novelty:** Invention has not been published, claimed or publicly used before the date of filing of a patent application
- **Inventive step**: Invention is capable of being made or used in any kind of industry
- **Industrial application:** The invention has not been published, claimed or publicly used before the date of filing of a patent application

Patentable subject matter:

Process and product can be patented

- A process or method
- A machine
- A manufactured article
- A new composition

Who can file patent application?

1. By any person claiming to be the true and first inventor of the invention.
2. By any person being the assignee of the person claiming to be the true and first inventor in respect of the right to make such an application.
3. By the legal representative of any deceased person who, immediately before his death, was entitled to make such an application.

General procedure for obtaining a patent

1. Filing of application

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2. Publication after 18 months
3. Filing of request for examination
4. Examination
5. Pre-grant opposition
6. Grant of patent
7. Post-grant opposition
8. Decision by controller

International patent grant procedure

- Application filled in a PCT contracting state
- International applications must be filled in a receiving office
- International search authority issues International search report and written opinion
- Publication of International application, ISR and written opinions
- International application enter National phase
- International application proceed under National laws

Patents in agriculture

1. Agricultural machines or implements, Soil working in agriculture or forestry (A01B). Ex: Seed-cum-fertilizer drill
2. Planting, sowing, fertilising (A01C). Ex: Process of manufacturing a slow release urea fertilizer by nitrification inhibition (Rashtriya Chemicals and Fertilizer Ltd.)
3. Harvesting and mowing (A01D). Ex: Self driven crop orienting three wheler harvester, two wheeler harvester (Punjab Tractors Ltd.)
4. Processing of harvested produce, devices for storing, agricultural and horticultural produce (A01F). Ex: Novel container for storeage/transportaion of fruits and vegetables (Bridge and Roof Co. Ltd.)
5. Horticulture, cultivation and forestry (A01G). Ex: Device separating stigma and style from the pistil of flowers (CSIR)
6. New plants or processes for obtaining them, plant reproduction by tissue culture technique (A01H). Ex: Method for enhancing nodulation activity and grain yeild in legumes (Southern Petrochemical Industries Corporation Ltd.)
7. Manufacture of dairy products (A01J). Ex: Process of production of immobilized milk clotting protease (CSIR)
8. Animal husbandry, silk rearing or breeding animals, new breeds (A01K). Ex: Method of degumming of silk using fungal protease (IIT and DBT)
9. Catching, trapping, apparatus for destruction of noxious animals (A01M). Ex: Insect repellent device (Reckitt & Colman of India Ltd.)
10. Biocides, pest repellants or attractants, plant growth regulators (A01N). Ex: Growth promoter from *Trichoderma harzianum* (CSIR)
11. Medicinal preparation containing materials from plants (A61K35/78). Ex: Herbal composition for treating asthma (CSIR)

Advantage of patent

1. **Exclusive Rights:** A patent grants the inventor exclusive rights to prevent others from making, using, selling, or distributing the patented invention without permission.
2. **Commercial Exploitation**: Patents provide inventors with the opportunity to commercially exploit their inventions by licensing or selling the patent rights to others, generating revenue streams.
3. **Market Advantage:** Having a patent can offer a competitive advantage in the market, as it prevents competitors from copying or imitating the invention, thereby maintaining market share and profitability.
4. **Incentive for Innovation**: Patents serve as incentives for innovation by providing inventors with legal protection and financial rewards for their creative efforts, encouraging further research and development.
5. **Asset Value**: Patents are valuable intangible assets that can enhance the value of a business, attract investors, and contribute to overall business growth and expansion.
6. **Legal Protection**: Patents offer legal protection against infringement, allowing inventors to enforce their rights through legal proceedings and seek remedies for any unauthorized use of their inventions.
7. **Public Disclosure:** Patent applications require disclosure of the invention's details,

contributing to the pool of scientific knowledge and promoting technological advancement through information sharing.

8. **Global Protection**: Patents can be filed and protected internationally, allowing inventors to secure their rights in multiple countries and access global markets.

Disadvantages of Patents

1. It involves cost of prosecution and renewal
2. It involves public disclosure of the invention
3. The validity is for short period
4. Patents are in territorial in nature

Conclusion

1. The economic, social and cultural development of nations and societies now depend more on intellectual resources than materials or natural resources
2. A patent may be viewed as a contract between the inventor and society. Both the inventor and society benefit from it
3. It encourages complete disclosure of an invention; it gives other inventors the opportunity to improve various features of the invention. So that it becomes more efficient and useful for scientific and economic progress of the nation
4. Patent provides protection to the patentee, wherein, if the patent is infringed, the patentee may seek legal remedies. Thus, a patent is a form of social security to an inventor

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5. PLANT BIOTECHNOLOGY

Gene Banks and Conservation of Plant Genetic Resources

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Summary

In response to escalating environmental challenges, the preservation of plant genetic resources has emerged as a critical imperative for global food security and agricultural sustainability. The importance of gene banks is underscored through their contributions to various aspects of agriculture, including facilitating the adaptation of crops to changing environments, conferring disease resistance, fostering innovation in crop improvement, and ensuring a stable food supply. This further explores diverse conservation methodologies employed in gene banks, encompassing traditional and modern techniques such as seed banking, in vitro conservation, field gene banks, and molecular techniques like DNA banking and cryopreservation. Gene banks are portrayed as indispensable guardians of plant genetic diversity, laying the groundwork for sustainable agriculture amid the challenges of

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climate change, emerging pests, and diseases. The call to support and strengthen gene bank initiatives is emphasized, highlighting the need for collaboration among scientists, policymakers, and the agricultural community to address conservation challenges and harness the potential of plant genetic resources for the benefit of humanity.

Introduction

In the face of evolving environmental challenges, the conservation of plant genetic resources has become a paramount concern for ensuring global food security and agricultural sustainability. Gene banks play a crucial role in this endeavor by preserving and protecting the genetic diversity of plant species. This article explores the importance of gene banks, the methodologies involved in conserving plant genetic resources, and the implications for the future of agriculture.

Importance of Gene Banks

1. **Adaptation to Changing Environments:** Genetic diversity provides the raw material for plant breeding programs, enabling the development of crops that can adapt to changing climatic conditions and evolving pests.
2. **Disease Resistance:** Gene banks house genetic material that may contain natural resistance to diseases. This can be invaluable in developing crops with built-in resistance, reducing the need for chemical interventions.
3. **Crop Improvement and Innovation:** Access to a diverse gene pool allows scientists and breeders to introduce novel traits into crops, fostering innovation and creating varieties with improved yield, quality, and nutritional content.
4. **Food Security:** Genetic diversity ensures a stable and resilient food supply. In the face of unpredictable environmental events or emerging threats, diverse plant genetic resources provide a safety net for agriculture.

Methods for Conservation of Plant Genetic Resources

The conservation of plant genetic resources involves a combination of traditional and modern techniques. Here are some key methodologies employed in gene banks are shown below.

1. **Seed Banking:** The most common method involves storing seeds at low temperatures to maintain their viability over extended periods. This is a cost-effective and practical approach for preserving a wide range of plant species.
2. **In vitro Conservation:** For species with recalcitrant seeds or those susceptible to genetic drift, in vitro conservation involves maintaining plant tissues, such as shoot tips or embryos, in a controlled environment. This method is particularly useful for preserving the genetic material of fruit trees and certain wild species.

3. **Field Gene Banks:** Some gene banks maintain live collections of plants in the field. This allows for the preservation of complex traits that may not be fully captured through seed storage alone.
4. **Molecular Techniques:** Advances in molecular biology, such as DNA banking and cryopreservation, enable the storage of genetic material in a highly compact form. These techniques contribute to the long-term preservation of plant genomes.

Conclusion

In conclusion, gene banks play a pivotal role in safeguarding the genetic diversity of plant species, providing a foundation for sustainable agriculture and global food security. The importance of these repositories cannot be overstated, considering the challenges posed by climate change, emerging pests, and diseases. By utilizing a combination of traditional and modern conservation techniques, gene banks contribute to the resilience and adaptability of crops in the face of a rapidly changing environment. As we move forward, it is essential to support and strengthen gene bank initiatives, ensuring the continued availability of diverse plant genetic resources for future generations. Collaboration between scientists, policymakers, and the agricultural community is crucial to addressing the challenges of conservation and harnessing the potential of plant genetic resources for the benefit of humanity.

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6. PLANT BIOTECHNOLOGY

Phytobiomes and Microbiome Engineering in Agriculture

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Summary

In recent years, agricultural research has spotlighted the exploration of phytobiomes and the revolutionary field of microbiome engineering. The phytobiome, encompassing plants, their environment, and the diverse microorganisms they interact with, is recognized as a crucial determinant shaping plant health, resilience, and productivity. Microbiome engineering, a specialized branch of biotechnology, focuses on manipulating these intricate microbial communities to optimize plant growth, amplify nutrient absorption, and fortify plants against environmental stresses. Within this realm, strategies such as introducing biocontrol agents, enhancing nutrient cycling, inducing disease resistance, developing stress-tolerant crops, and designing customized microbial consortia are employed. Despite the vast potential, challenges like the dynamic nature of microbial communities and ethical considerations persist. Nonetheless, ongoing research aims to refine microbiome engineering techniques for practical application in agriculture. Phytobiomes and microbiome engineering offer a promising frontier in sustainable agriculture, providing eco-friendly solutions to enhance productivity and resilience by unraveling the intricate relationships between plants and their microbial partners.

Introduction

In the contemporary landscape of agricultural research, the investigation into phytobiomes and the revolutionary field of microbiome engineering has become a focal point. The phytobiome, an intricate amalgamation of the plant, its surroundings, and the diverse array of microorganisms it engages with, stands as a critical determinant in molding not only the health and resilience of plants but also their overall productivity. Within the realm of biotechnology, microbiome engineering has emerged as a specialized branch dedicated to the manipulation of these complex microbial communities. The primary objectives of microbiome engineering revolve around the precise calibration of these microscopic ecosystems to optimize plant growth, amplify nutrient absorption processes, and fortify plants against an array of environmental stresses. Through strategic interventions at the microbial level, microbiome engineering aims to unlock the potential for sustainable agricultural practices. By delving into the dynamic relationships between plants and their microbial partners, this innovative approach promises to usher in a new era of crop management. From bolstering disease resistance to enhancing nutrient utilization efficiency, microbiome engineering holds the promise of revolutionizing the agricultural landscape. As we navigate the uncharted territories of phytobiomes and microbiome engineering, the profound impact on agricultural sustainability and productivity unfolds, offering a glimpse into the future of environmentally conscious and resilient crop management.

Understanding Phytobiomes

Phytobiomes involves exploring the intricate and dynamic ecosystems formed by the interactions between plants and the diverse community of microorganisms in their surrounding environment. The term "phytobiome" encompasses not only the plant itself but also the soil, water, and the vast array of microorganisms such as bacteria, fungi, viruses, and archaea that reside in and around the plant.

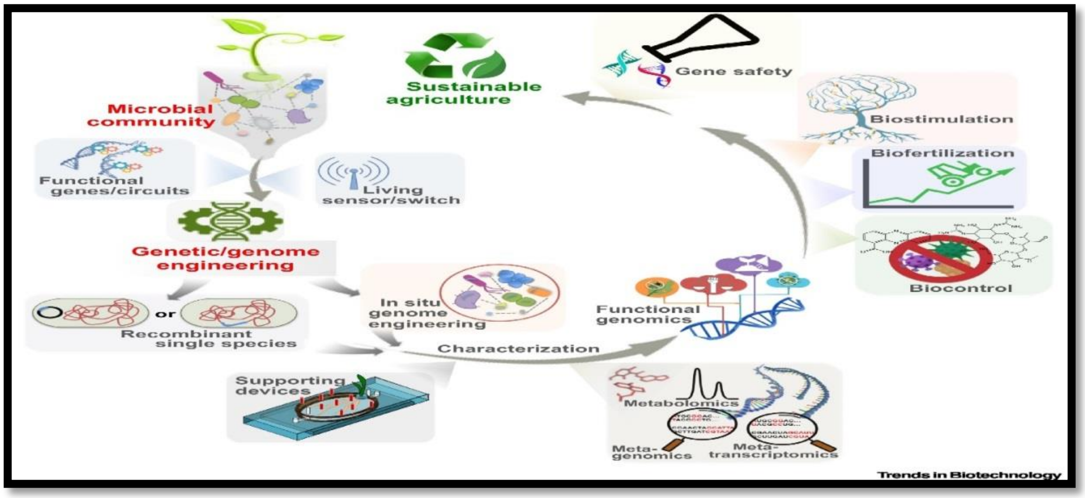
Key Aspects of Understanding Phytobiomes

1. **Microbial Diversity:** Phytobiomes are characterized by a rich diversity of microorganisms that form symbiotic relationships with plants. These microorganisms contribute to the overall health and functioning of the plant ecosystem.
2. **Symbiotic Relationships:** The microorganisms in the phytobiome engage in complex symbiotic relationships with plants. Some microorganisms provide essential nutrients to the plant, enhance nutrient uptake efficiency, and contribute to overall plant growth.
3. **Nutrient Cycling:** Microorganisms in the phytobiome play a crucial role in nutrient cycling. They participate in processes such as nitrogen fixation, making nutrients more available to plants and influencing the overall nutrient balance in the ecosystem.
4. **Disease Dynamics:** Understanding phytobiomes is essential for unraveling the dynamics of plant diseases. Certain microorganisms within the phytobiome can act as pathogens, causing diseases, while others can be beneficial, offering protection against pathogens through mechanisms like induced systemic resistance.
5. **Environmental Interactions:** Phytobiomes are influenced by environmental factors such as soil composition, climate, and agricultural practices. Research in this area aims to elucidate how these factors shape the composition and functioning of phytobiomes.
6. **Technological Advances:** Recent advancements in DNA sequencing technologies and metagenomics have revolutionized the study of phytobiomes. These tools allow scientists to analyze the genetic material of entire microbial communities, providing insights into their composition and functional potential.

Microbiome Engineering for Sustainable Agriculture

In the quest for sustainable agriculture, scientists are turning to the intricate world of microbiomes for innovative solutions. Microbiome engineering, a upcoming field within biotechnology, seeks to manipulate the diverse communities of microorganisms associated with plants to enhance crop productivity, resilience, and environmental sustainability.

Microbiomes, consisting of bacteria, fungi, viruses, and other microorganisms, establish symbiotic relationships with plants. These partnerships influence nutrient cycling, disease resistance, and overall ecosystem health. Recognizing the potential of these microbial allies, researchers are now employing microbiome engineering strategies to revolutionize agricultural practices.



Strategies in Microbiome Engineering:

1. **Biocontrol Agents:** Microbiome engineering involves introducing beneficial microorganisms to the plant environment, acting as natural defenders against harmful pathogens. These biocontrol agents help reduce the need for chemical pesticides, promoting environmentally friendly and sustainable pest management practices.
2. **Enhanced Nutrient Cycling:** Microbes within the soil microbiome play a crucial role in nutrient cycling. Microbiome engineering aims to optimize these microbial communities to enhance nutrient availability for plants, promoting efficient nutrient uptake and reducing the need for synthetic fertilizers.
3. **Disease Resistance:** By manipulating the composition of the plant-associated microbiome, researchers can induce systemic resistance in crops. This strengthens the plant's natural defense mechanisms, making it more resilient to various diseases and reducing the impact of yield-limiting pathogens.
4. **Abiotic Stress Tolerance:** Microbiome engineering contributes to developing crops with increased tolerance to environmental stressors such as drought, salinity, and extreme temperatures. Certain microbial communities can help plants thrive in challenging conditions, mitigating the effects of climate change on agriculture.
5. **Customized Microbial Consortia:** Advances in synthetic biology enable the design and implementation of custom microbial consortia. Tailored to specific crop and environmental conditions, these consortia can optimize plant-microbe interactions for improved agricultural outcomes.

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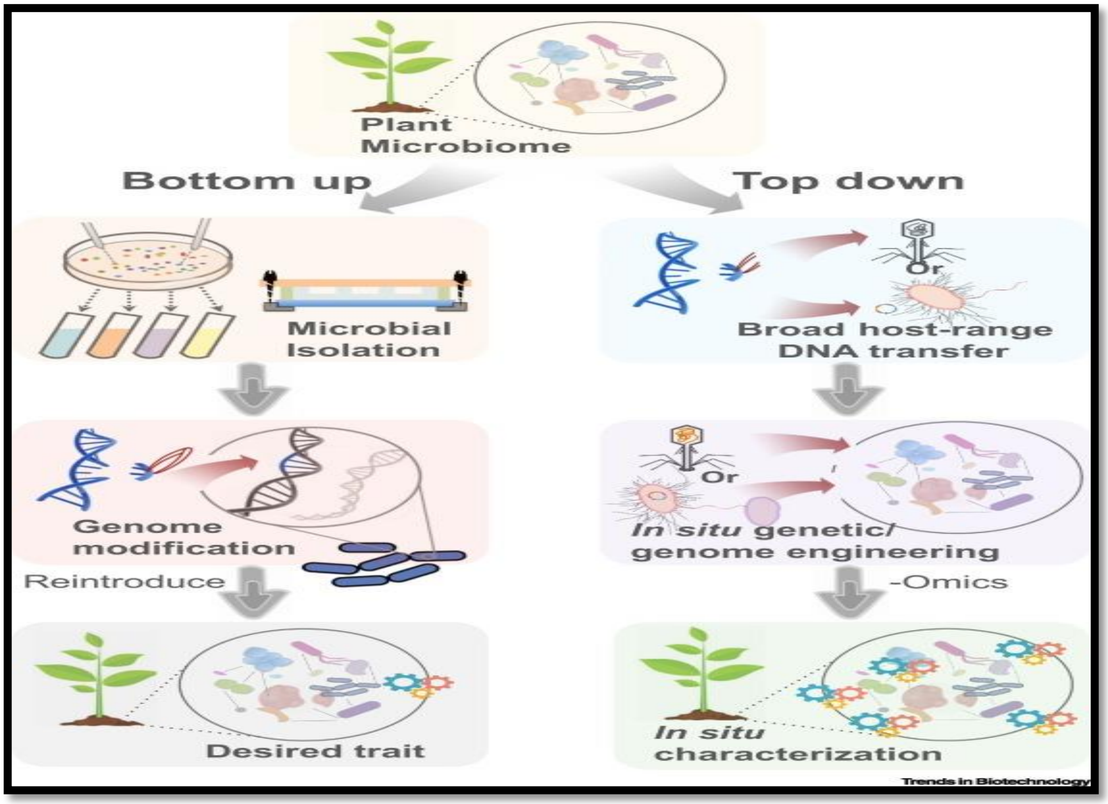

Challenges and Future Prospects

While the potential of microbiome engineering is vast, challenges such as the dynamic nature of microbial communities, environmental variations, and ethical considerations surrounding genetically modified organisms persist. Ongoing research aims to address these challenges and refine microbiome engineering techniques for practical application in agriculture.

Conclusion

Phytobiomes and microbiome engineering represent a promising frontier in sustainable agriculture. As we delve deeper into the intricate relationships between plants and their microbial partners, the potential to revolutionize crop management practices becomes increasingly evident. By unlocking the secrets of the phytobiome, researchers are paving the way for innovative and eco-friendly solutions to enhance agricultural productivity and resilience.

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7. PLANT BIOTECHNOLOGY

The Omics Revolution: Transforming Science at the

Molecular Level

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Summary

Omics technologies, including genomics, transcriptomics, proteomics, and metabolomics, have revolutionized molecular biology, providing comprehensive insights into living organisms. They offer unprecedented understanding by analyzing genes, transcripts, proteins, and metabolites. The suite of methodologies has transformed biological exploration, impacting diverse scientific disciplines. These technologies play a crucial role in precision agriculture and crop improvement, focusing on genomics for genetic diversity, transcriptomics for gene expression, proteomics for protein functions, and metabolomics for metabolic insights.

Omics applications in crop improvement involve marker-assisted breeding, understanding gene expression patterns, functional proteomics for stress responses, and metabolic pathway analysis. Integrated multi-omics approaches enable a systems biology approach, facilitating predictive modeling for crop responses to environmental changes. However, challenges such as data complexity, functional annotation, and ethical concerns exist, alongside limited access to advanced technologies.

Introduction

In the ever-evolving landscape of scientific discovery, omics technologies have emerged as transformative tools, revolutionizing our understanding of biology at the molecular level. The term "omics" refers to comprehensive approaches that analyze various biological components, such as genes, transcripts, proteins, and metabolites, providing unprecedented insights into the complexity of living organisms.In the dynamic landscape of scientific inquiry, the advent of Omics technologies has ignited a revolutionary transformation, fundamentally altering the way we perceive and investigate the intricacies of life at the molecular level. This suite of high-throughput methodologies, including genomics, transcriptomics, proteomics, and metabolomics, has become the linchpin of modern biological exploration. Omics technologies offer an unparalleled ability to unravel the complex web of biological molecules within organisms, ushering in a new era of comprehensive understanding. This article explores the profound and revolutionary impact of Omics technologies, delving into their applications across diverse scientific disciplines, the challenges they present, and the promising future they herald for scientific discovery. As we navigate through the intricacies uncovered by these groundbreaking technologies, the depth and breadth of their impact continue to reshape the landscape of biological research and redefine the boundaries of what we thought possible.

Omics Technologies Includes:

Genomics

Genomics focuses on the study of an organism's complete set of DNA, unraveling its genetic code. This has far-reaching implications, from understanding genetic variations among individuals to mapping entire genomes of species. The Human Genome Project, a landmark genomics initiative, marked a milestone by sequencing the entire human genome, serving as a foundational reference for subsequent genomic studies (International Human Genome Sequencing Consortium, 2004).

Transcriptomics

Transcriptomics delves into the world of RNA, examining the complete set of transcripts within a cell or tissue. This aids in understanding gene expression patterns, alternative splicing events, and regulatory mechanisms. RNA sequencing technologies, such as RNA-Seq, have become indispensable tools for unraveling the complexities of gene expression (Wang, Gerstein, & Snyder, 2009).

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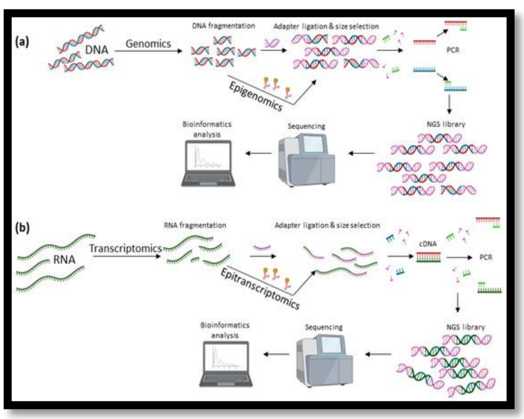
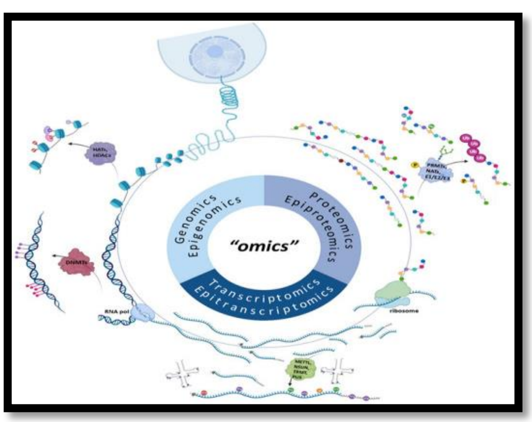
Proteomics

Proteomics explores the entire complement of proteins expressed by an organism. By identifying and quantifying proteins, proteomics sheds light on cellular functions, signaling pathways, and disease mechanisms. Advancements in mass spectrometry have significantly enhanced the precision and depth of proteomic analyses (Aebersold & Mann, 2003).

Metabolomics

Metabolomics provides a snapshot of an organism's metabolites, offering insights into biochemical pathways, cellular metabolism, and responses to environmental stimuli. This field has gained prominence in understanding diseases, metabolic disorders, and plant-microbe interactions (Fiehn, 2002).





Applications of omics technologies in crop imorovement

Omics technologies have ushered in a new era of precision agriculture, offering transformative applications in crop improvement. These comprehensive methodologies, including genomics, transcriptomics, proteomics, and metabolomics, provide valuable insights into the molecular intricacies of plants. Here's a brief overview of how Omics technologies contribute to enhancing crop traits, resilience, and overall productivity:

1. Genomics in Crop Improvement
   a. **Genetic Variation:** Genomic studies unveil the genetic diversity within plant populations, enabling the identification of key genes associated with desirable traits (Varshney et al., 2018).
   b. **Marker-Assisted Breeding:** Genomic markers assist in the selection of plants with desired traits, accelerating the traditional breeding process (Collard and Mackill, 2008).
2. Transcriptomics for Gene Expression Studies
   a. **Understanding Gene Expression:** Transcriptomics allows researchers to study gene expression patterns in response to various environmental conditions, stresses, or developmental stages (Wang, Gerstein, & Snyder, 2009).
   b. **Identifying Key Regulatory Elements:** Insights into regulatory networks help identify genes responsible for specific traits, guiding targeted interventions for crop improvement.
3. Proteomics for Protein Expression Profiling
   a. **Functional Proteomics:** Proteomic studies provide a comprehensive understanding of protein functions, aiding in the identification of key proteins associated with stress responses, disease resistance, and nutrient utilization (Aebersold & Mann, 2003).
   b. **Biomarker Discovery:** Proteomics contributes to the discovery of protein biomarkers associated with specific physiological conditions, facilitating crop monitoring and management.
4. Metabolomics for Comprehensive

Metabolic Profiling

a. **Metabolic Pathway Analysis:** Metabolomics elucidates the metabolic pathways within plants, helping to identify key metabolites related to stress tolerance, nutritional content, and overall health (Fiehn, 2002).

b. **Phenotyping for Crop Traits:** Metabolomic profiling aids in phenotyping, allowing for the assessment of plant traits related to quality, flavor, and nutritional value.

5. Integrated Multi-Omics Approaches

a. **Systems Biology:** Integrating data from genomics, transcriptomics, proteomics, and metabolomics enables a systems biology approach, providing a holistic understanding of the molecular interactions within plants (Liu et al., 2015).

b. **Predictive Modeling:** Multi-omics data facilitate the development of predictive models for crop responses to environmental changes, guiding the development of stress-resistant and high-yielding varieties.

Mechanism of Different Omics Technologies for Crop Improvements

Omics technologies encompass a suite of high-throughput methodologies that systematically analyze biological components at the molecular level, providing comprehensive insights into the intricate workings of living organisms. The mechanisms of key omics technologies—genomics, transcriptomics, proteomics, and metabolomics—are outlined below:

1. **Genomics: Mechanism:** Genomics involves the study of an organism's complete set of DNA, or genome. High-throughput sequencing technologies decode the genetic code, identifying genes, regulatory elements, and variations in DNA sequences.
2. **Transcriptomics: Mechanism:** Transcriptomics focuses on the study of the complete set of RNA transcripts within a cell or tissue. RNA sequencing (RNA-Seq) techniques quantify and analyze gene expression levels, alternative splicing, and non-coding RNA.
3. **Proteomics: Mechanism:** Proteomics explores the entire complement of proteins within a biological sample. Mass spectrometry and other techniques identify and quantify proteins, elucidating their functions, post-translational modifications, and interactions.
4. **Metabolomics: Mechanism:** Metabolomics examines the complete set of small molecules (metabolites) involved in cellular processes. Techniques such as mass spectrometry and nuclear magnetic resonance (NMR) identify and quantify metabolites.
5. **Integrated Multi-Omics Approaches: Mechanism:** Integrated multi-omics approaches involve combining data from genomics, transcriptomics, proteomics, and metabolomics. Systems biology techniques analyze these integrated datasets to comprehend the holistic molecular interactions within a biological system.

Challenges and Future Prospects Of Omics Technologies For Crop Improvement

Challenges

1. **Data Integration and Analysis Complexity:** The massive amount of data generated by omics technologies poses a significant challenge in terms of integration and analysis.
2. **Functional Annotation and Validation:** Assigning functions to all identified genes and molecules remains a bottleneck in translating omics data into practical applications.
3. **Phenotype-Genotype Linkage:** Establishing a clear and reliable linkage between genotypic variations revealed by omics technologies and the corresponding phenotypic traits is complex.
4. **Ethical and Regulatory Issues:** The application of omics technologies in crop improvement raises ethical concerns related to genetically modified organisms (GMOs) and regulatory frameworks.
5. **Limited Access to Advanced Technologies:** Many developing regions and smaller research institutions may have

limited access to state-of-the-art omics technologies.

Future Prospects

1. **Precision Breeding and Targeted Crop Improvement:** Omics technologies will enable precise breeding strategies, allowing for targeted improvement of specific traits such as yield, nutritional content, and stress tolerance.
2. **Resilience to Climate Change:** Omics data can contribute to the development of climate-resilient crops by identifying key genes and pathways involved in stress response, helping breed crops with enhanced adaptability.
3. **Personalized Agriculture:** Tailoring crop varieties to specific agroecological conditions using omics technologies can optimize agricultural practices, promoting sustainable and efficient food production.
4. **Integration with Digital Agriculture:** Omics technologies will play a pivotal role in the integration of molecular data with digital agriculture platforms, facilitating real-time monitoring and decision-making for farmers.
5. **Synthetic Biology and Designer Crops:** Combining omics data with synthetic biology approaches will enable the design of crops with custom traits, leading to the development of designer crops tailored to meet specific market demands and environmental conditions.

Conclusion

Omics technologies have transformed our ability to decipher the intricate molecular tapestry of life. From decoding the human genome to enhancing crop resilience, these technologies continue to redefine the boundaries of scientific understanding. As we navigate the complexities revealed by Omics, the future promises unprecedented breakthroughs that will shape the landscape of biology and scientific inquiry for years to come. The Omics revolution is not merely a technological advance but a paradigm shift, unlocking the secrets of life with profound implications for the future of scientific discovery.

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8. PLANT BIOTECHNOLOGY

Non-Conventional Breeding Approach in Sesamum

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Summary

Sesame (Sesamum indicum L.) holds a significant position as an ancient oilseed crop.It is cultivated globally for its nutritional, medicinal, and industrial applications. Sesame varieties, characterized by diverse seed colors and oil content, are cultivated in several Indian states, including Gujarat, Madhya Pradesh, Rajasthan, Maharashtra, Odisha, and Andhra Pradesh. The crop's importance lies in its high oil content (45-52%), protein (27%), and diverse applications in food, medicine, cosmetics, and alternative fuel. Despite its historical significance, sesame faces limitations in productivity due to factors like indeterminate growth, non-synchronous maturity, and vulnerability to pests and diseases. As oilseed consumption rises, there is a renewed scope for genetic improvement in sesame, focusing on both conventional and non-conventional breeding approaches. Conventional breeding involves exchanges between closely related species, while non-conventional methods, such as genomic selection (GS), CRISPR-Cas9 technology, marker-assisted selection (MAS), and wide hybridization, offer more targeted and efficient ways to enhance desirable traits. Genomic selection uses genomic data to predict breeding values and accelerate the selection of superior genotypes. CRISPR-Cas9 allows precise gene modification for improvements in disease resistance, yield, and oil composition. Marker-assisted selection speeds up breeding by using molecular markers linked to desirable traits, and wide hybridization introduces novel genetic diversity for increased resilience.

Introduction

Sesame (*Sesamum indicum* L., 2n=2x=26), belonging to the family Pedaliaceae is commonly known as til and tila is an important oilseed crop. This crop is often known as “Queen of Oilseeds”. Sesamum is the one of the oldest oilseed crops known domesticated well over 3000 years ago. Worldwide, it is used for its nutritional, medicinal, and industrial purposes. Most wild species originated in Africa and cultivated type *Sesamum indicum* L. originated in India.It grown in India, China, Korea, Russia, Turkey, Mexico, South America and several countries of Africa.

Varieties

In India there are various varieties with different seed colour and with variation in oil content as shown in following table

Sr.No	State	Varieties	Seed Colour
1	Gujarat	Guj.til-1,2,3 Guj.til-10	White seed Black seed
2	Madhya pradesh	TKG-21,22,55,306,308, JTS-8, PKDS-11,12 , PKDS-8	White seed Dark brown Black seed
3	Rajasthan	RT46,103,125,127,346,351, RT-54	White seed Light brown
4	Maharashtra	AKT-64,AKT101,AKT306, JLT-408, Phule til -1 PKVNT-11	White seed
5	Odisha	Nirmala,Subhra, Prachi, Amrit Smark (golden yellow)	White seed Black seed Golden yellow
6	Andhra pradesh	Varaha, Gautama, Swetha til, Hima	Brown seed White seed

Importance

- Among oilseeds crops, sesame is the most ancient oilseed known and grown by humans according to archaeological records.
- Sesamum contains about 45-52% oil, 27% protein, 6-7% moisture, 16% carbohydrate and 6-8% crude fiber.
- The oil contains several fatty acids such as oleic acid (43%), linoleic acid (35%), palmitic acid (11%) and stearic acid (7%) with trace amount of

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linolenic acid and also has the highest antioxidant presence.

- Sesame oil reduces hypertension and ease stress and protects against antibiotic induced kidney damage.
- Sesame oil is also used for the manufacturing of soaps, cosmetics, hair oils, perfumes, insecticides, and pharmaceutical products.
- Sesame oil can also be used as an alternative diesel fuel by mixing with methanol and sodium hydroxide.

Limitations of Sesame Cultivation

- ➢ There are various reasons for low productivity of sesame as sesame cultivation is mainly done as underutilized crop with poor management in marginal and sub marginal lands.
- Indeterminate growth habit non-synchronous maturity, vulnerability to pests and diseases etc. makes the overall production in a stagnant situation.

Scope

- The oilseeds have been somewhat neglected in the past fifty years due to the advent of green revolution.
- India has achieved major landmarks in the production of cereal crops such as paddy, wheat, maize etc. in last fifty years.
- Meanwhile, the rising income of people has meant that the consumption of oilseeds has been on the rise constantly.

This has created a need for genetic improvement in Sesame.

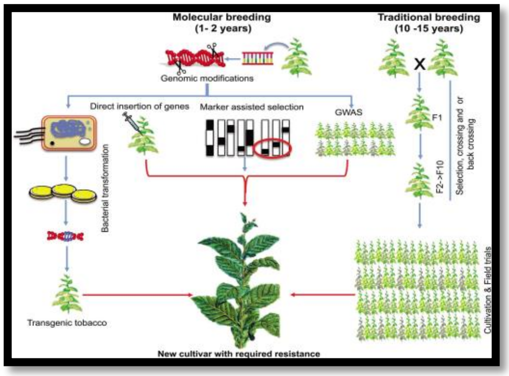
Breeding Approaches

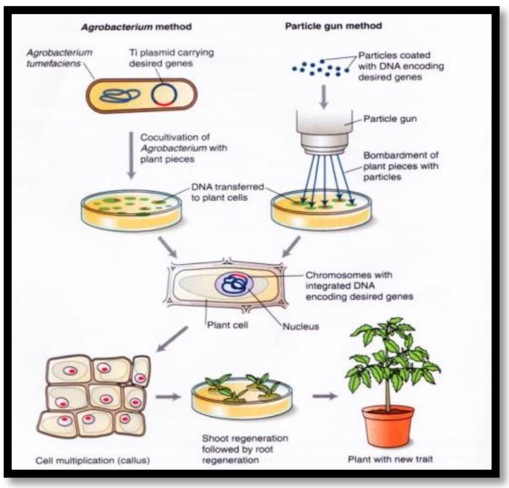
There are two breeding approaches shown in following table:

Conventional	Non conventional
Limited to exchanges between same or very closely related species	Allows the direct transfer of one or just a few genes between either closely distantly related species
Takes long time to achieve desired traits	Crop improvement cane be achieved in shorter time
Little or no guarantee of any particular gene combination from the million of crosses generated	Allows plants to be modified by removing or switching off particular genes
Undesirable genes can be transferred along with desirable genes	Only desirable genes can be transferred

Non-Conventional Breeding Approaches

1. **Genomic Selection (GS):** Genomic selection involves the use of genomic data to predict the breeding value of plants. By analyzing the entire genome, breeders can identify specific genes associated with desirable traits. In sesame, GS has shown promise in accelerating the selection of superior genotypes for improved yield, resistance to biotic and abiotic stresses, and enhanced nutritional content.
2. **CRISPR-Cas9 Technology:** Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and CRISPR-associated protein 9 (Cas9) technology allows precise modification of specific genes, enabling targeted improvements in sesame traits. This revolutionary tool offers the potential to enhance disease resistance, increase yield, and optimize oil composition in sesame varieties.
3. **Marker-Assisted Selection (MAS):** MAS involves the use of molecular markers linked to desirable traits to speed up the breeding process. In sesame, MAS has proven effective in selecting plants with resistance to diseases such as Fusarium wilt. This approach allows for more precise and efficient breeding by focusing on specific genomic regions associated with target traits.
4. **Wide Hybridization:** Wide hybridization involves crossing sesame with closely related species to introduce novel genetic diversity. This approach can enhance traits like tolerance to drought, heat, and pests. Successful wide hybridization efforts can contribute to the development of more resilient and adaptable sesame varieties.





Conclusion

Non-conventional breeding approaches in sesame offer exciting possibilities for overcoming traditional limitations and elevating the crop's productivity and resilience. By integrating genomics, CRISPR-Cas9 technology, marker-assisted selection, and wide hybridization, breeders can unlock the full genetic potential of sesame, ensuring sustainable production to meet the growing global demand for this valuable oilseed crop. As research in this field progresses, the future holds promising prospects for improved sesame varieties with enhanced traits, contributing to global food security and agricultural sustainability.

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9. HORTICULTURE

Packaging of Fruit Produce; Improve Storage and Maintain Quality

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Introduction

India has second rank in the production of fruits in the world after china.In India total production of fruits about 99069 ('000 MT) during 2019-00 **(Anonymous, 2020)**of which about 20% loss due to improper packaging. Packaging is a process of wrapping or placement of objects in paper or other packaging material, keeping in box, etc. we can minimize the post- harvest loss due to packaging by suitable packaging method.More than1500 different type of packages are used for produce.

Importance of Packaging

The increased production of fruits will have significance only when they reach the consumer in good condition at a reasonable price. Packaging of fruits is undertaken primarily to assemble the produce in suitable units for marketing and distribution.The package must be capable of protecting the produce from the hazards of transport, preventing microbial and insect damage, and minimizing physiological and biochemical changes.

Packaging is also a medium of communication by providing identity and information of the product which motivate the consumers buy.Packaging of distribution play the key role in growth of both fresh and processed fruits industry.Packaging forms an integral part of producers, handling, processors and consumers.Packaging and related areas engage about 60% of the 5 million labour force concerned with the Indian food industry (Thompson, 1996).

Qualities of An Ideal Packaging

It should not affect the flavor of the product packed inside of it.Sufficient thickness of cushioning materials with sufficient ventilation.Sufficient space for rapid cooling of content. Protect the content from oxygen, moisture and light. Compatible to the food product.Closure characteristics such as opening, sealing, resealing, and pouring.Proper labeling, strong marketing, appeal to promote the sale of food product.Low cost and availability.

Type of Containers

1. **Field containers: -** Picking containers are of many type depending upon the crop region and availability of materials. Picking bags of canvas, mesh hampers and bamboo are widely used.
2. **Shipping containers:-** In India , baskets and boxes are often used as containers. Fiberboard cartons are becoming popular for shipping both tropical and sub tropical fruits.
3. **Consumer packages:-** Use of small sized packages for produce has grown with the increase in large self–service markets for retailing. Bags, plastic films and mesh bags are used as consumer packages.
4. **Shrink–film wraps:-** Films such as polypropylene, polystyrene and polyethylene can be converted into shrink films covering of the materials.

Method of Packaging Materials

- Bulk packaging
- Pre-packaging containers

1. **Bulk packaging**

The materials of bulk packaging are of various type such as:-

a. Baskets:- Basket are made up of various local material such as bamboo, mulberry, pigeon pea, etc. These are of various capacity, shapes and sizes.
b. Wooden boxes:- It is not a great moisture or gas barrier and can be a source of microbial contamination, particularly by moulds.
c. Rigid plastic crates:- Plastic crates available in various sizes, shape and colour and made up of high density polyethylene. These are strong, rigid, reusable and can be cleaned easily. The normal capacity varies from 20 to 40 kg.
d. Corrugated fiber board boxes:- Corrugated fiber board boxes ventilation can be provided easily and can be laminated with plastic film as per need.
e. Plastic corrugated box and sacks:- Plastic corrugated box made up of polypropylene and high density polyethylene are better than corrugated fiber board boxes due to their high degree of moisture resistance, reusability and low weight, very expensive and have low compression strength and cushioning property.

2. **Pre-packaging containers**

Pre-packaging reduces spoilage, increase shelf life both under normal and cold storage condition and offers hygienic method of distributions and storage. The materials of pre-packaging are of various type such as:-

a. Plastic bag:- Plastic bags (polyethylene film) are the predominate material for fruits consumer packaging. The film material "breathes" at a rate necessary to maintain the correct mix of oxygen, carbon dioxide, and water vapor inside the bag.
b. Trays with over wraps:- Tray with over wrap material are used to hold individual fruits. The film made of low density polyethylene or polyvinyl chloride used to cover the trays as over wrap.
c. Plastic crate of light weight:- This made light density polyethylene which has high compression strength. The crates have perforation for ventilation.
d. Shrink wrap:- Shrink wrapping with an engineered plastic wrap can reduce shrinkage protect the produce from disease, reduce mechanical damage and provide a good surface for stick–on labels**(APEDA, 2005).**

Modified Atmospheric Packaging

It can be defined enclosure of food product barrier film in which the environment has changed modified to slow respiration rates, reduced microbiological growth and retards enzymatic spoilage with intent of standing the self-life (Kader, 1980).

1. Passive MAP: Commodity is sealed packed in package or films result permeability of O_2 is reduced and concentration of CO_2 is increased automatically.
2. Active MAP: Commodity is sealed packed in package and gas is pulled out slightly creating vacuum. Ethylene absorbers and CO_2 scrubbers can keep inside the package.

Oxygen absorbers: FerrousOxide.

CO_2 absorbers: Hydrated lime, aluminium calciumsilicate, Activated carbon.

Ethylene absorbers: Silica gel, Alumina pallets Ethysorb(Commercial preparation).

Benefits of MAP

Reduction of respiration rate and ethylene production. Inhibition of ripening and senescence. Minimization of water loss and nutrient decomposition. Inhibition of microbial growth, physiological disorders and spoilage. Extension of shelf life with retention of quality attributes.

Vacuum Packaging

The commodity is packed in an air tight container and pressures are reduced by sucking air and creating vacuum in container**.**

Mechanism

Reduced O_2 supply slows down respiration. When pressure reduces 1atm to 0.1 atm theeffective O_2 concentration reduces from 21 to 2.1%.Released ethylene is removed out of package.

Example of Modern packaging materials

1. **Paper packaging** e.g. paper boards, moulded pulp trays, laminated paperboard cartons, tetra packs, etc.
2. **Plastic containers** e.g. polyethylene films, cellulose films, polypropylene films, others.
   a. They offer more adequate protection from microbial attacks, insects and foreign materials of the environment.
   b. There have good provision for caps and closures in several of them.

Factors affecting of packaging

- Climatic effects
- Physical damage
- Contamination by micro-organisms, insects and other foreign matters.

Moisture and gases: - Transfer of moisture, oxygen and carbon dioxide through packaging materials is critically important in determining shelf life and quality of chilled fresh foods packaged in modified atmospheres.

Microorganisms: - Main causes of microbial contamination of adequately processed foods are air or water drawn through pinholes in hermetically sealed containers, contamination of heat seals by products, poorly aligned lids or caps and damage to packaging materials.

Mechanical strength: - Ability of packages, to product foods from mechanical damage is measured by tensile strength, impact strength and other mechanical strength properties.

Light: - Light transmission is required in packages that are intended to display contents but is restricted when foods are susceptible to deterioration by light.

Heat:- Insulating effect of a package is determination by its thermal conductivity and its reflectivity. Materials which have a low thermal conductivity (eg. Paper board) and reflective materials (eg. Aluminum foil) reflect radiant heat.

Conclusion

Packing makes a bridge between production and marketing. It protects the produce at all stages of transportation, storage and marketing in addition to protection, packaging allows quick handling throughout distribution and marketing and can minimize impacts of rough handling packing dose not improve quality but retains quality. Packaging can bring revolutionary progress in our trade practice and also benefit the consumer and producer because of its low cost and ready availability.

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10. HORTICULTURE

Effect of Plant Bio-Extract Based Edible Coating on Post Harvest Physiology and Quality of Horticultural Commodities

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Horticultural crops constitute a major part in total agricultural area & production. Fruit and vegetables are the integral part of healthy human diet due to various vitamins, minerals & antioxidant properties. They are perishable in nature and due to lack of effective value addition chain 25-50 % loss observed during postharvest stages. Availability of poor transportation and insufficient post harvest management & value addition facilities which are responsible causes for heavy post harvest loss of perishable commodities. Scientists are trying to reduce post harvest decay by using various methods to prolong the shelf life of fresh products, like that low temperature and high relative humidity, CA & MA packaging, etc. Among these tools edible coating is a safest as well as effective. Formation of an edible layer outside the fruit surface by coating agents is a promising alternative for improving quality and preservation of food during processing and storage. Application of coating agents on fruit prior to marketing is an important postharvest treatment applied to improve visual appearance as well as extend shelf life. Edible coating provides a partial physical barrier against moisture loss; gas and solute movement thus regulate the respiration process and retard the physiological ripening process, retain volatile compounds, and maintain firmness of fruits (Dhall 2013). Various agents have been used alone or in combination to make edible coating these are Polysaccharides, proteins & lipids etc. Films and coatings usually can be produced from the same formulation. Application of coating is done in liquid form before forming the coating meanwhile application of films are as solid sheets. Formulation of films & coatings are prepared according to specific requirement for food preservation because the properties of a coating on the surface of a biological matrix cannot be characterized, isolated films have been reported as an alternative for predicting coating properties.

What is Edible Coating

Edible coatings are thin layers of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings and to provide a barrier to moisture, oxygen, and solute movement for the They are applied directly on the food surface by dipping, spraying, or brushing to create a modified atmosphere because they will be consumed, the material used for the preparation of edible films and coatings should be generally regarded as safe (GRAS) approved by FDA and must conform to the regulations that apply to the food product concerned (Guilbert *et al.,* 1996). An ideal coating is defined as one that can extend storage life of fresh fruits and vegetables without causing anaerobiosis and reduces decay without affecting their quality. Previously, edible coatings have been used to reduce water loss, but recent developments of formulated edible coatings with a wider range of permeability characteristics has extended the potential for fresh produce application (Park *et al*., 1994).

Properties of Edible Coatings

The properties of edible coating depend primarily on molecular structure rather than molecular size and chemical constitution. Specific requirements for edible films and coatings are (Arvanitoyannis and Gorris, 1999). The coating should be economical, water-resistant, non-sticky, low viscosity and reduce water vapor permeability. Also it should not deplete oxygen or build up excessive carbon dioxide. It should improve appearance, maintain structural integrity, improve mechanical handling properties, carry active agents (antioxidants, vitamins, etc.) and retain volatile flavor compounds. It should melt above 40◦C without decomposition.

What is Plant Bio-extract..?

A plant extract is a substance or an active with desirable properties that is removed from the tissue of a plant, usually by treating it with a solvent, to be used for a particular purpose. Usually plants contain many types of chemical constituents like alkaloids, glycosides, organic acids, resins, volatile oils, sugars (including starches, inulin, gums and phlegmatic, etc.) , amino acids, proteins and enzymes, tannins, plant pigments (including chlorophyll, carotenoids, flavonoids, beet red bases and quinones, etc.), oils and waxes, and inorganic ingredients (trace elements). Extracts may be used in various sectors of activities: Food and functional properties for foodstuffs (antioxidant, texturizer, etc.), Processing aids, additives–chemical replacers, pharmaceutical for therapeutic properties - preventive and/or curative – cosmetic for functional properties for beauty and well-being etc. *Ficus hirta,* Meadowsweet Flower Extract & Grapefruit seed extract coating with various agents and Locust bean gum coatings enriched with pomegranate peel extract has the potential to prolong the postharvest life and maintain the fruit quality (Chen *et al.* 2016, Aloui *et al.* 2014). These all coatings are the natural, safe and eco-friendly and useful in postharvest management (Kharchoufi *et al.* 2018).

Method of Coating application

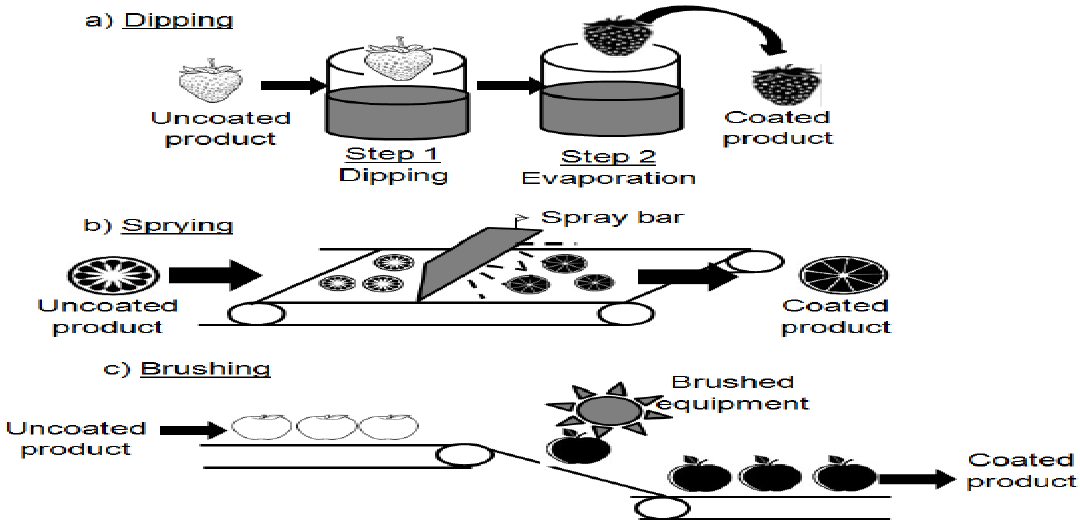
1. **Dipping** It is the most commonly used technique for applying food coatings. In this method fruits & vegetables are dipped into coating solution for a specific time.
2. **Spraying** Spray coating is also most commonly used technique for applying food coatings. A spray system increases the surface area of the liquid through the formation of droplets and distributes them over the food surface area by means of a set of nozzles.
3. **Brushing** In this method brush is dipped into coating solution and then after applied onto fruit or vegetables.

Advantages of Edible Coatings

Advantages of edible coatings (Dhall 2013)

1. It improves external appearance of fruit surface and maintains weight and reduces respiration rate and ethylene production, thus delaying senescence.
2. Prevents fruits and vegetables against chilling injuries and storage disorders.
3. Act as barrier to free gas exchange.
4. Provides a carrier for postharvest chemical treatments.
5. Encapsulates aroma compounds, antioxidants, pigments, ions that stop browning reactions and nutritional substances such as vitamins.
6. Reduces the use of synthetic packaging

material.



Challenges and Disadvantages of Edible Coatings

Fruits and vegetables are usually commodities with very high water activity, and it is well known that the capacity of films to function as barriers to water vapor and gases decreases as relative humidity of the environment increases. The capacity of edible films to have low permeability to water and gases relies on external conditions like temperature and relative humidity and characteristics of the film such as chemical structure, polymer morphology, degree of cross linking, solvents used in casting film, and type of plasticizer used. Coatings casted from ethanol had lower WVP, O_2, and CO_2 permeability than those casted from water. Nevertheless, if ethanol is used as a solvent for a coating formulation in fruits and it is not completely evaporated, it can impart a bad flavor or be used by the fruit as a substrate to produce volatile compounds that could be undesirable. The application of an artificial barrier to diffusion of gases and water by coating of fresh-cut fruits causes a modification of the atmosphere inside the fruit that could lead to a decrease in the production of characteristic flavor compounds. Adding some compounds to the coating formulation that can be used by the fruit to produce acetate esters could compensate such deficiency. Limited oxygen diffusion caused by the presence of edible coatings on fruit may limit respiration processes to an extent that forces fruit to undergo anaerobic respiration, metabolizing glucose into ethanol. Control of oxygen permeability of coatings and monitoring of ethanol production by fruits is extremely important, since exposure of cut-fruit to ethanol conduces to the formation of off-flavors, even when exposure is limited to short periods of time and prolonged exposure of fruit to anaerobic conditions results in cellular death.

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11. PLANT PATOLOGY

Microsphere Immunoassay Technology: A Way to Multiplex Detection of Plant Pathogen

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Rapid and accurate detection of plant pathogens helps in protecting and preventing the spreading of plant disease. To date, many classical single reaction methods based on determination of nucleic acids such as polymerase chain reaction (PCR), quantitative real-time PCR (qPCR), reverse transcription PCR (RT-PCR) and reverse transcription quantitative PCR (RT-qPCR), or antibody-based tests like enzyme-linked immunosorbent assays (ELISA) techniques are available for the detection of plant pathogens. Microsphere immunoassay technology is an advanced technique, which simultaneously detect multiple plant pathogens in a single biological sample. These techniques enable analysis of large numbers of samples. rapid, sensitive, specific and cost-effective molecular diagnostics, their ability to simultaneously detect multiple analytes in a single reaction.

Working Principle

The xMAP (Multi- Analyte Profiling) technology is a multiplex assay format, that uses polystyrene beads (microspheres) dyed with distinct proportions of red and near-infrared fluorophores which are classified by using digital signals processors, the analyzer reads multiplex assay results by reporting the reactions occurring on each individual microsphere.

Procedure

The xMAP technology uses magnetic microsphere, which differs in size and structure through the addition of the magnetic layer. Magnetic microspheres is made from polystyrene, which have an additional layer of magnetite within the polymer layer. The polymer layer, which is formed polystyrene divinyl benzene core surrounded by a polystyrene methacrylic acid (infusion of dyes) and the surface of each microsphere is irregular, porous and carboxylated. Usage of magnetic beads improves washing efficiency as the magnetic separation step enables the elimination of unwanted sample constituents. The technique involves 100-member microsphere are internally dyed with two spectrally different fluorophores. Integration of a third internal dye has allowed the expansion of upto 500-member microsphere sets. Each beads canbe identified by the unique concentration of dyes. These microsphere beads is further conjugated with a reagent specific to a particular bioassay. The reagents may include antigens, antibodies, oligonucleotides, enzyme substrates, or receptors. In plant pathogen detection, the antigen are bound to the microspheres conjugated with specific antibodies and a magnet is used to separate the bound and non-bound microspheres. After the separation, specific antibodies linked with a reporter fluorophore are added to the microsphere-sample mix. A Luminex xMAP analyser excites the internal dyes of the microspheres with a red laser and the reporter fluorochrome, captured by the antigen, with a green laser, allowing the specific detection of multiple analytes at the same time.

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Table 1: List of plant diseases detected by using microsphere immunoassay technology

Crop	Disease	Reference
Watermelon & Chillie	*Acidovorax avenae subsp.citrulli* *Chilli vein banding mottle virus* *Watermelon silver mottle virus* *Melon yellow spot virus*	*Charlermroj et al., 2017*
Potato	*Pectobacterium atrosepticum* *Dickey dianthicola*	*Peters et al., 2014*
Potato	*Potato virus x,* *Potato virus Y,* *Potato leaf roll virus*	*Bergervoet et al., 2008*
Tomato, Chillie & Melon	*Capsicum chlorosis virus (CaCV) Watermelon silver mottle virus (WSMoV)* *Tomato necrotic ringspot virus (TNRV)* *Melon yellow spot virus (MYSV)*	*Seepiban et al. 2011*

Advantages of microsphere immunoassay technology

- A large number of different bioassays can be performed and analysed simultaneously.
- A single xMAP Technology-based system can perform bioassays in several different formats, including nucleic acids and antigen-antibody binding, along with enzyme, receptor-ligand, and other protein interactions.
- The technology generates real-time analysis and accurate quantification of the biological interactions

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12. AGRONOMY

The Critical Role of Zinc (Zn) In Plant Production

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Introduction

The use of micronutrients in soil is the pillars of agriculture in developed countries. Proper plant nutrition is one of the most important factors in improving the quality and quantity of plants product. Among the micronutrients, zinc plays a vital role in plant growth and development. In general zinc have main role in synthesis of proteins, enzyme activating, oxidation and revival reactions and metabolism of carbohydrates. In plants, zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes and proteins in many important biochemical pathways and these are mainly concerned with: carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens (Alloway, 2008). Its deficiency retards photosynthesis and nitrogen metabolism, reduces flowering and fruit development, prolongs growth periods (resulting in delayed maturity), decreases yield and quality, and results in sub-optimal nutrient-use efficiency.

Zinc deficiency in soil

Zinc has emerged as the most widespread micronutrient deficiency in soils and crops worldwide, resulting in severe yield losses and deterioration in nutritional quality. It is estimated that almost half of the soils in the world are deficient in zinc. The Food and Agriculture Organization of the United Nations (FAO) estimates that 50% of world's soils growing cereal grains are zinc deficient. India is no exception. Analysis of over 256,000 soil samples from all over India showed that about 50% of the soils were deficient in zinc and that this was the most common micronutrient problem affecting crop yields in India. Zinc deficiency in India is expected to increase from the present level of around 50% to 63% in 2025 if the current trend continues. This is also because increasing areas of marginal lands are brought under intensive cultivation without adequate micronutrient supplementation.

Zinc deficiency in plants

Zinc deficiency symptoms appear on the young leaves of plants first; because zinc cannot be transferred to younger tissues from older tissue. Areas between nervure in plants are yellow by zinc deficient. In dicot plants internode distance and leaf size will be short and in monocot plants, corn especially, bands comes into the main nervure on both sides of leaves in zinc deficient condition Overall, shoot is more affected than the root growing by zinc deficiency (Mousavi, 2011).

Zinc toxicity

When zinc amount is excessive, causes toxicity in plants. Leaf and root growth and development decreased by zinc toxicity. Production of NADPH in plant chloroplasts are decreases with increasing zinc concentration. In addition, production of free radicals will increase in plants. Activity of RUBP carboxylase enzyme and Photosystem II decreases by zinc toxicity. Zinc toxicity reduces ATP synthesis and chloroplasts activity and photosynthesis will decline as a result. Also, large amounts of zinc reduce uptake of P and Fe. More than 300ppm of zinc in plant caused toxicity. (Prasd *et al.,* 1999). Most crops are tolerant to high zinc levels in their tissues without visible symptoms. Cereals are sensitive to zinc toxicity. Typical toxicity symptoms are iron chlorosis and lack of green colour in the leaves.

Zinc in plant production

The Zn plays very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome. Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, and regulation of auxin synthesis and pollen formation. The regulation and maintenance of the gene expression required for the tolerance of environmental stresses in plants are Zn dependent. Its deficiency results in the development of abnormalities in plants which become visible as deficiency symptoms such as stunted growth, chlorosis and smaller leaves, spikelet sterility. Micronutrient Zn deficiency can also adversely affect the quality of harvested products; plants susceptibility to injury by high light or temperature intensity and to infection by fungal diseases can also increase. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. As Zn is required for the synthesis of tryptophan which is a precursor of

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IAA, it also has an active role in the production of an essential growth hormone auxin (Brennan, 2005). The Zn is required for integrity of cellular membranes to preserve the structural orientation of macromolecules and ion transport systems. Its interaction with phospholipids and sulphydryl groups of membrane proteins contributes for the maintenance of membranes.

Challenges in zinc fertilizer use

Major challenges faced by farmers towards use and promotion of zinc fertilizer products are:

- Unavailability of zinc fertilizers at the time of need of the farmers
- Poor quality of zinc fertilizers available in the market
- Zinc fertilizers under highly unorganized and fragmented sector
- Lack of awareness of the extension and promotional workers
- Lack of awareness of the farmers – last mile delivery

Conclusion

Zn is very essential plant nutrient for all types of crops. It is deficient in all parts of the globe with different types of soils. Correcting zinc deficiency will improve crop yields and farmers' incomes, while improving nutritional quality of crops and thus human nutrition. Balanced fertilizer use with micronutrients including zinc is necessary for higher crop yields. Urgent need to increase awareness among farmers and extension workers for increased use of zinc fertilizers.

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