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Hydroponics: A Boon for Vegetable Crops

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Introduction

Since the day, India overtook China as the most populous country in the world now the more, there is an alarming need of food for that population. Due to rapid urbanization and industrialization, the land is getting less for cultivating crops too. So, how to cultivate crops especially vegetable crops that are required by every person on daily basis in this scenario? Hydroponics farming is the answer. This essay delves into the importance of hydroponics, exploring the advantages of it in cultivating vegetable crops and the future aspects of it.

Hydroponics in CRISP

It is derived from two Greek roots: “hydro” means water and “ponein” means to labor or work. Therefore, a plant is said to be hydroponic when it is grown by using special nutrients dissolved in water rather than on land. Simply, it is a technique of growing plants in soil- less culture with the roots immersed in nutrient solution. The beginning of this type of farming has been in India since 1946 and was introduced by an English Scientist, W.J. Shalto Duglas.

Quality Vegetable Production

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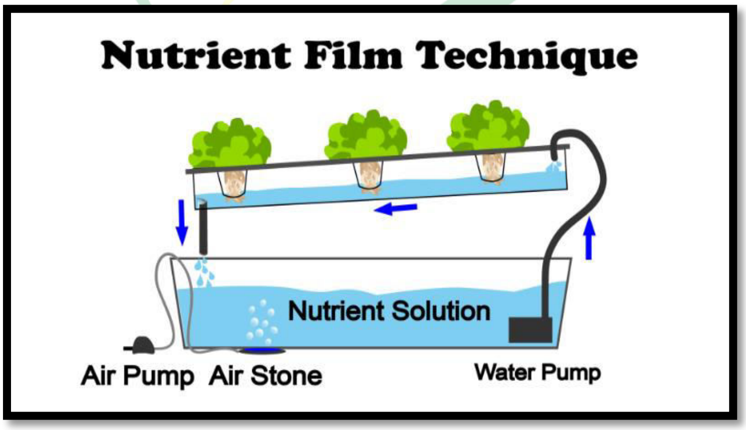
During 1930s. the first modern use of this technique was done by W.F. Gerike from the University of California to grow tomatoes, beets, carrots and potatoes etc. This increases crop quality and productivity which ultimately results in higher competitiveness and economic returns. Various crops can be grown commercially by this method which includes leafy vegetables, tomato, cucumber, pepper etc.

Types

4 main types of hydroponic system are-

- Nutrient film technique (NFT)
- Dynamic root floating technique
- Water culture technique
- Ebb and flow method

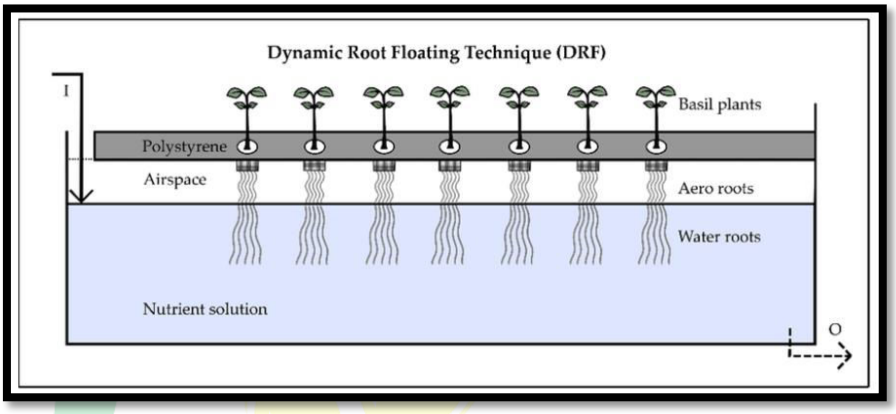
1) **NFT-** one of the most popular systems



- Developed in mid 1960s by Dr. Allen Cooper
- In this, channels are built from plastic or wood and are lined with polyethylene plastic. The channels are tilted and the water is collected and reused by the pump.

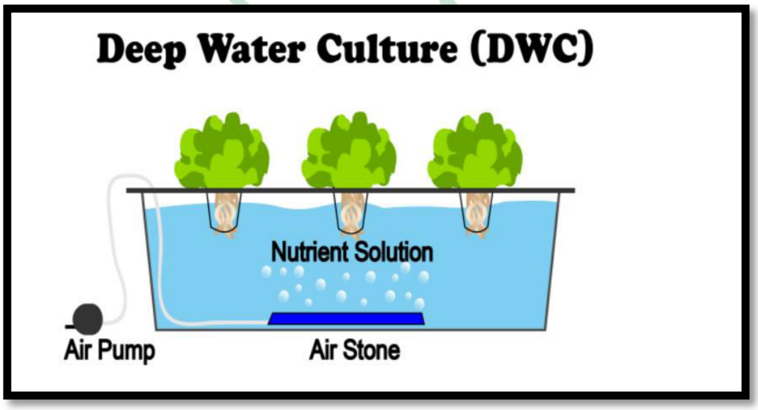
- Thin film of nutrient solution flows through the channel constantly.
- A pump is used to circulate water throughout the channel.
- Therefore, also known as circulating/closed method or continuous flow solution culture.
- Spinach can be grown all around the year by this technique in greenhouse.

2) Dynamic root floating technique



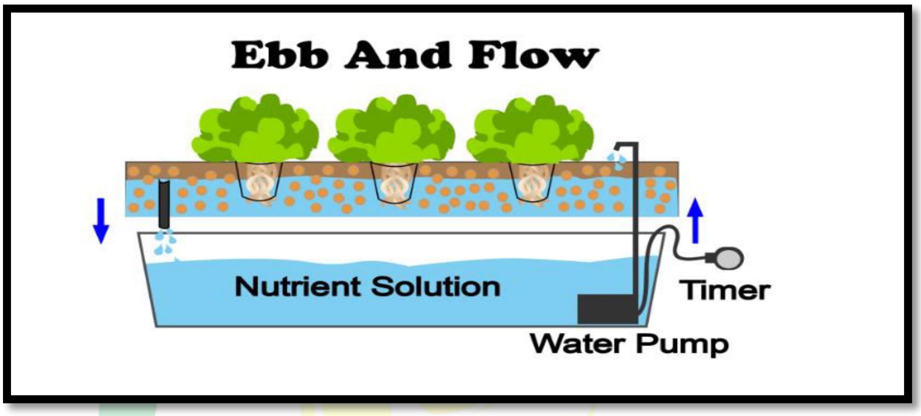
- It was developed by The Taichung District Agricultural Improvement Station in 1986.
- Similar to NFT, nutrient solution is passed through one end and allowed to move around through all the channels before collected back into the reservoir again.
- Here the water pump is turned onn and off in a constant manner unlike NFT.
- The lower part of the roots droops down in nutrient solution for nutrient uptake (nutriroots) while the upper part is not submerged and is accountable for oxygen uptake (aeroroots).
- It is most suitable for tropical and sub-tropical climate like that of Thailand.

3) Water culture technique



- In this technique, plant roots are dangled in nutrient rich solution and air is supplied directly to the roots with the help of air stone.
- Roots should remain in complete darkness to prevent the growth of nutrient consuming algae.
- Effective method for cultivating lettuce, cucumber and tomato.

4) Ebb and flow method



- It is based on the principle of flood and drain.
- In this, water is pumped into the tank and then allowed to drain in a gradual way. As the water drains, the roots got exposed and receive more oxygen.
- From this moist rooting medium, plants obtain water and nutrient elements.
- This method is good for small plants like basil or parsley.

Conclusion

Due to the dramatic change in our lifestyle, climate change, hazardous infections, increasing urbanization and depletion of natural resources are becoming a major threat to human beings. To alleviate these threats to our agricultural system, hydroponic farming is the solution. The growing of crops using controlled environment is the major benefit of this technique. It has a prospective to provide fresh, local food even to the environment with severe droughts and low soil quality. In country like India, the scope of hydroponics in future is very good in a way that, since agriculture is the major consumer of water and by this technique one can save up to 80% of water usage. Moreover, with the help of readily available nutrient solution, plants can grow up 50 % faster than in soil condition. For large corporations also, it can be regarded as an excited and potential task.

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Hydroponics: An Innovative and Sustainable Approach toModern Agriculture Technology in the 21st Century

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Abstract

Hydroponics technology is a soil-less agricultural technology that has gained significant consideration in recent years due to its potential for efficient and sustainable production. This innovative approach involves growing plants in nutrient-enriched water solutions and its ability to maximize yields, conserve water, and provide precise control over plant growth and essential elements such as nutrients, pH, and water makes it a valuable tool for addressing the challenges of food production in an urbanized world. Many different types of plants, crops, and vegetables may be produced with hydroponics. In general, hydroponically generated end products have superior quality yields, tastes, and nutritional values than naturally occurring soil-based agriculture. It is becoming more and more well-liked worldwide, in both developed and developing nations, because of its low cost, lack of sickness of the crops, and eco-friendly practices. Along with advanced space research, it has a lot of potential in many nations to fill the gap in arable land when suitable cultivable land is unavailable. Using hydroponics to meet the global nutrition demand will make a significant contribution to the future of food supply. Hydroponics is an emerging approach that might be used to feed the world's population in the future.

Keywords: Hydroponics, soilless, Sustainable, Nutrient enriched, Eco-friendly, and Sickness

Introduction:

Hydroponics is an approach to cultivating plants in nutrient-enriched water rather than soil, with or without the use of mediums such as vermiculite, coconut coir, perlite, peat moss, etc. (Radhakrishnan *et al.,* 2019). These mediums provide mechanical support to plant roots

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and ensure they have access to the required nutrients. Instead of obtaining nutrients from the soil, hydroponic plants receive a balanced mixture of water and nutrients. This allows for better control over the plant's nutritional intake, leading to faster growth and healthier crops. Hydroponics is also known as "aquaculture" or "tank farming."

History:

Hydroponics gets its name from the Greek word hydro, which means water, and ponos, which means labor (Beibel *et al.,* 1960). The earliest published study on growing plants without soil is in F. Bacon's book "Sylva Sylvarum", which was released in 1627, a year after his death (Ghatage *et al.,* 2019). John Woodward reported his spearmint water cultivation research in 1699. He discovered that plants growing in pure water sources outgrew those growing in distilled water. In the early 1930s, Professor William Gericke used the term "hydroponics" to refer to the practice of growing plants with their roots suspended in water that contains nutrients and minerals with or without the use of mediums such as vermiculite, coconut coir, perlite, peat moss, etc. (Jan *et al.,* 2020).

Nutri-culture was developed by researchers at Purdue University in 1940 for growing crops. During the 1960s, the nutrient film technique was first developed by Allen Cooper in England and was first used in the food industry, but it has now been widely adopted. Hydroponics has the largest market in Europe, where the top three manufacturers are France, the Netherlands, and Spain. The United States of America and the Asia-Pacific area are the next two largest markets, respectively (Jan *et al.,* 2020). According to Jensen and Collins' 1985 analysis, the global hydroponic market was predicted to grow at a rate of 18.8% between 2017 and 2023, with a projected value of USD 490.50 million.

In 1946, W. J. Shalto Duglas brought hydroponics to India and set up a laboratory in Kalimpong, West Bengal (Bhattacharya, 2017). Additionally, he is the author of the book "Hydroponics: The Bengal System".

Why hydroponics:

It is estimated that the global population will be 50% larger than it is today by 2050, while the demand for grain will double as well (Tilman *et al.,* 2002). Because of this, soil-based agriculture will face massive challenges for both the sustainability of food production and the sustainability of terrestrial and aquatic ecosystems, as well as urbanization and industrialization, in the upcoming decades. Nevertheless, at the same time, it is expected that

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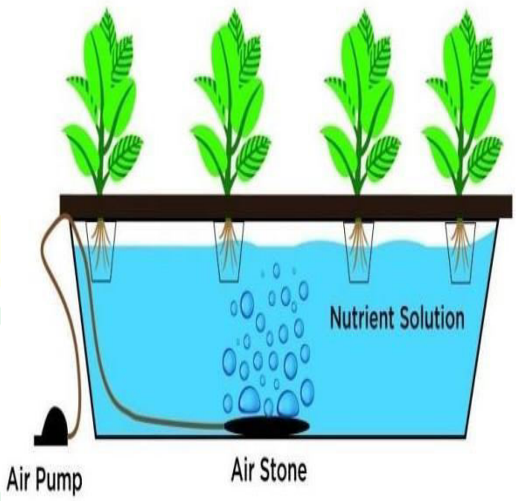
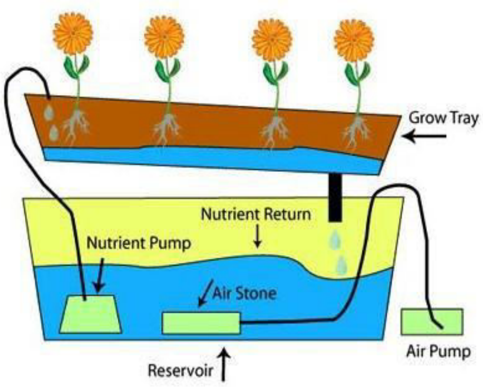
soil fertility and quality will also decline due to climate change, natural disasters, and uncontrolled use of chemicals for agricultural purposes. Consequently, to overcome the current situation and ensure the future of the country, researchers have developed an alternate method of growing plants called hydroponics, or soilless agriculture. Now, this type of agriculture is becoming more and more popular worldwide, in both developed and developing nations, as it is economical, disease-free, and eco-friendly. In many nations, it offers excellent potential in conjunction with high-altitude research to address the scarcity of arable land in situations where suitable cultivable land is unavailable. Therefore, hydroponics would be a better technique to fulfill the demand for nourishment in the world while also producing a variety of fruits, vegetables, and feed while advancing the future.

Types of hydroponics:

1. **Deep water culture:** In DWC systems, roots are immersed in nutrient-enriched aerated water with plants floating in a nutritional solution. The roots are supplied with oxygen via air-stones and an air pump. In reservoirs, oxygen, nutrient concentrations, salinity, and pH must be monitored to avoid algae and mold growth (Jones, 2005).





2. **Nutrient film technique:** It was developed by Dr. Allen Cooper in England in the 1960s. In this system, a thin layer of nutrient solution constantly flows over the roots of the plants in a shallow, sloping channel (Morgan, 2009). There is a small amount of water around the roots of the plants, which is the main reason for naming this method NFT.

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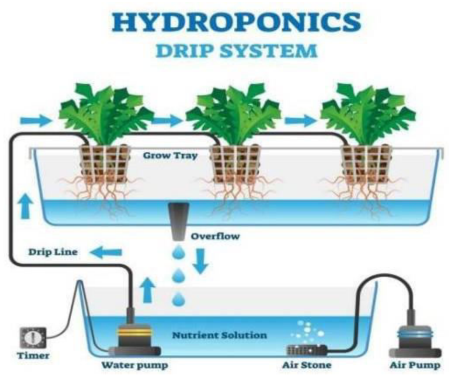
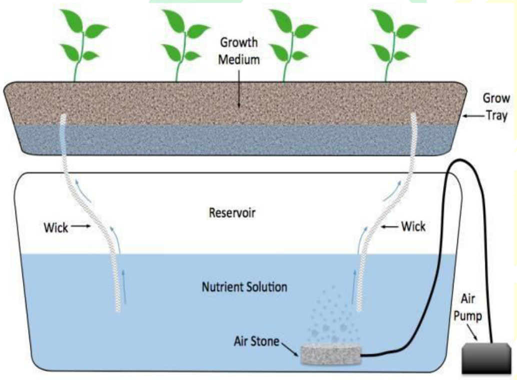
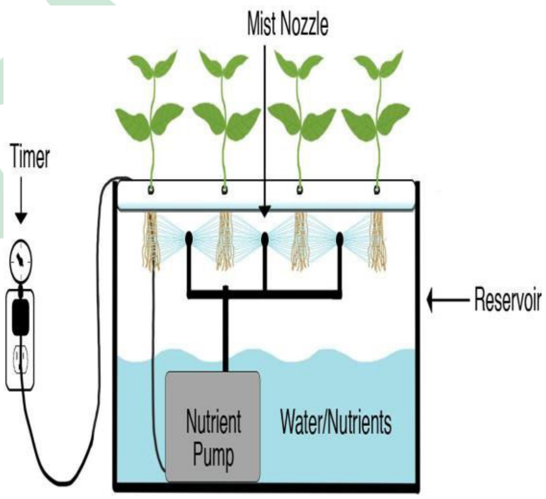
3. **Drip system:** In this system, the plants are grown independently in a soil-less medium, and the nutrient solution is kept separate in a reservoir. Drip systems supply nutritional solutions or water to the roots of the plants via emitters or nozzles to slowly drip nutrients and any excess solution may be collected, recycled, or even let to drain off.

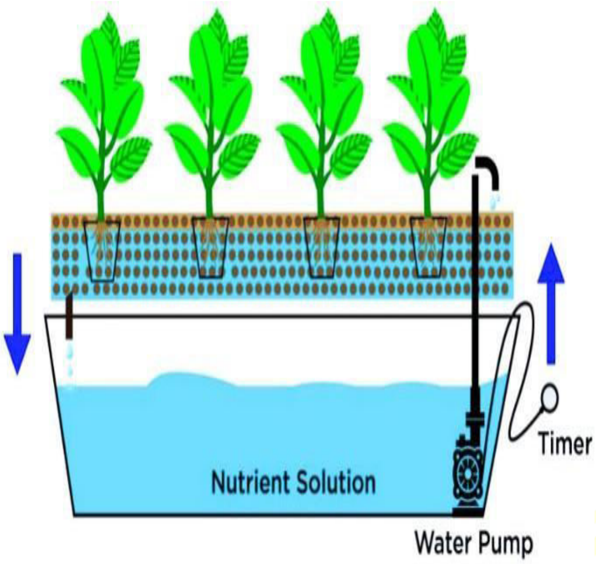




4. **Wick system:** The wick system is one of the simplest hydroponic systems. They use a wick (usually made of cotton or felt) to draw the nutrient solution from a reservoir to the plant's roots. This method is suitable for small-scale, low-maintenance operations (Lee and Lee, 2015).

5. **Aeroponic technology:** It is a newer and more advanced method of technology for growing plants. This approach doesn't require a growing medium like the nutrient film technique. The plant roots are directly suspended in an environment, and the plants are misted with a nutrient-enriched water solution as they grow to keep the environment moist (Kumari and Kumar, 2019).





6. **Ebb and flow technology:** It is also known as "flood and drain hydroponics". According to this system, plants are grown in a soil-less medium and periodically flooded with a nutrient- enriched water solution by using a pump that is placed into the reservoir and allowing it to drain back into the reservoir. It supplies oxygen to roots, and it helps to prevent over-watering.

Hydroponics techniques- Basic requirements:

1. **Growing medium:** Medium doesn't provide any nutrients for the plants; it provides only mechanical support to the roots. Ex: vermiculite, coconut coir, perlite, peat moss, etc.
2. **Nutrient solution:** It is a vital component in hydroponic systems, where plants are grown without soil. It provides a total of essential nutrients like macro-nutrients (N, P, K, Ca, Mg, S, etc.) and micro-nutrients (Mn, B, Fe, Mo, Na, Co, etc.) directly to the plant's roots in a water- based environment.
3. **Water:** It could be essential to measure the pH and ensure that no contaminants or diseases are present.
4. **Temperature and Humidity:** Maintaining the temperature and humidity is essential for healthy plant growth.
5. **Mineral nutrients:** According to De Saussure and Boussingault (1800), carbon, hydrogen, oxygen, and nitrogen play a significant role in the growth of plants. After that, in 1860, Sachs and Knop, added phosphorus, potassium, calcium, magnesium, and sulfur to the list of De Saussure and Boussingault, and grew plants in aqueous solutions. Later, research in plant physiology has revealed that plants require other micronutrients, such as zinc, copper, manganese, boron,

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molybdenum, iron, and boron, to grow properly (Velazquez-Gonzalez *et al.,* 2022)

Macro-nutrients	Micro-nutrients
1. **Carbon:** The building block of biological substances	10. **Boron:** Essential for procreation.
2. **Hydrogen:** Water Formation	11. **Manganese:** Component of chlorophylland is used to activate enzymes
3. **Oxygen:** Sugar's energy release	12. **Iron:** A component of photosynthesis
4. **Nitrogen:** The synthesis of proteins,amino acids, and chlorophyll	13. **Copper:** Activation of enzymes
5. **Phosphorus:** Essential for ATP synthesis and photosynthesis	14. **Zinc:** An ingredient in auxins andenzymes
6. **Potassium:** Essential for the activity ofthe enzymes and osmotic regulation	15. **Sodium:** Essential for the movement of water
7. **Calcium:** The building block of the cell wall, cell development, and cell division	16. **Chlorine:** Activation of enzymes
8. **Magnesium:** An ingredient of chlorophyll, an enzyme that activates	17. **Cobalt:** Fixation of nitrogen
9. **Sulfur:** Essential proteins and aminoacids synthesis	18. **Molybdenum:** Fixation of nitrogen
	19. **Nickel:** For nitrogen release

6. **Aeration and Pumps:** Many hydroponic systems require the use of water pumps to circulate the nutrition solution as well as air pumps to oxygenate the solution and prevent rootrot, which is one of the biggest problems.
7. **Lighting:** In hydroponics, proper illumination is essential to plant development. Either natural sunshine or artificial grow lights, including fluorescent, high-intensity discharge (HID), or light-emitting diodes (LEDs), can be used.

Advantages of hydroponics:

1. High water usage efficiency.
2. A small area is needed for hydroponics.
3. Plants may be grown vertically to maximize yield per square meter.
4. Hydroponic plants develop more quickly and are less susceptible to diseases and pests.
5. There is no need for soil tillage, and it is an odorless approach without the use of

fertilizers.

6. Reduce pesticide use.
7. Soil conservation or prevent soil erosion.
8. Crops are cultivated throughout the year.

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Hydroponics Farming

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Introduction

Hydroponics is a technique to nurture plants which utilizes water instead of soil. The mineral fortified water provides plants with all the nutrition they require. These nutrients come from the decomposition of organic matter in the soil in conventional soil-based agriculture. Nonetheless, there are wide variations in soil quality, and drainage, pH balance, and nutrient availability can all have a big impact on crop yields. A nutrient solution, typically composed of various macro and micronutrients, is delivered to the plant roots, ensuring they receive the optimal balance of elements for growth and development. This soilless technique offers numerous advantages over traditional soil-based agriculture, making it an increasingly popular choice for both commercial and home growers (Maharana and Koul, 2011). This method is gaining popularity due to its numerous advantages, including higher yields, efficient water usage, reduced pest and disease problems, and year-round cultivation. Hydroponics offers a sustainable and efficient approach to agriculture, addressing the challenges of food production in a growing global population (Vega *et al.,* 2021).

Types of Hydroponic Systems

1. **DeepWater Culture (DWC):** Plants roots are suspended in a continuously flowing nutrient solution, providing constant access to nutrients and oxygen.
2. **Nutrient Film Technique (NFT):** A thin film of nutrient solution is periodically flushed over the plant roots, ensuring efficient nutrient uptake.
3. **Drip System:** Nutrient solution is precisely dripped onto the plant roots, minimizing water waste and allowing for customized nutrient delivery.
4. **Aeroponics**: Plant roots are suspended in a mist of nutrient solution, maximizing oxygen exposure and nutrient absorption

Types of Hydroponic Growing Media

There are many different types of hydroponic growing media available, each with its own unique properties and advantages. Some of the most common types of growing media include:

- **Rockwool**: Molten rock is spun into fibres to create the synthetic substance known as Rockwool which is expensive and is an ideal choice for hydroponics because it is sterile, lightweight, and water retention capacity.
- **Coconut coir**: Coconut coir is a natural material made from the husks of coconuts which is sustainable, renewable resource and relatively inexpensive. Coconut coir is a better candidate for hydroponics because it is porous, holds water well, and provides good aeration.
- **Perlite**: Made from volcanic rock, perlite is a lightweight, porous substance. High temperatures cause it to expand, becoming even lighter and more porous. Its sterility, light weight, and excellent aeration make it a viable option for hydroponics. Perlite does not, however, hold water as well as many other growing media.
- **Vermiculite**: When heated, the naturally occurring mineral vermiculite expands. Its sterility, light weight, and excellent water-holding capacity make it an excellent choice for hydroponics. Additionally, vermiculite has a huge surface area that might aid in holding nutrients and offers adequate aeration.
- **Expanded pellets (LECA):** Expanded clay pellets (LECA) are small, porous clay beads that are lightweight and provide good aeration. They are also reusable and pH neutral, making them a good choice for hydroponics.
- **Rice hulls:** Rice hulls, byproducts from the rice business, due to their lightweight, porous nature, and excellent aeration make them a viable option for hydroponic systems. Nonetheless, rice hulls could require more frequent replacement than other growing media since they can absorb nutrients from the fertilizer solution.

Precautions for Using Hydroponic Growing Media

1. Always sterilize your growing media before use. This will assist in limiting the spread of infections and pests. Ensure that the growth media has adequate drainage. This will assist in avoiding root rot.
2. Aerate your growing media regularly. This will help to ensure that your plants have access to oxygen.

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3. Monitor your nutrient solution carefully. This will help to prevent nutrient deficiencies or toxicities.
4. With careful planning and attention to detail, hydroponic growers can use growing media to create healthy and productive crops.

Advantages of Hydroponics Farming

It is gaining popularity due to its versatility. It can be practiced even in floodplains in order to attain food security and to empower the farmers livelihood (Kumar and Parida, 2021). The key advantages of hydroponic farming is illustrated in Figure 1 which makes it a viable choice in combating the multifaceted issues arising in crop production.

- **Enhanced Productivity:** Hydroponics enables plants to absorb nutrients directly, eliminating the need for extensive root systems and allowing them to focus on growth. This leads to faster growth rates, increased yields, and earlier harvests.
- **Water Conservation:** Hydroponic systems employ water-efficient irrigation techniques, recirculating nutrient solutions and minimizing evaporation losses. Compared to traditional soil-based agriculture, hydroponics can reduce water consumption by up to 90%.
- **Pest and Disease Control:** The controlled environment of hydroponic systems minimizes the risk of pest infestations and soil-borne diseases which facilitates growing healthy crops without any application of any agrochemicals.

Figure 1. Advantages of Hydroponic Farming

- **Year-Round Cultivation:** Hydroponic setups can be located indoors or outdoors, allowing for year-round cultivation regardless of seasonal conditions. This is particularly advantageous in regions with severe conditions or scant arable land.

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- **Space Optimization:** Hydroponic systems are ideal for urban areas with limited land availability because they may be stacked vertically, optimising space utilisation and enabling more efficient crop production in a smaller area (Sharma *et al.,* 2018).

Disadvantages

While hydroponics offers numerous advantages, it also has certain drawbacks that should be considered before adopting this method of farming.

- **High Initial Cost:** Setting up a hydroponic system can be expensive, especially for larger-scale operations. The initial investment includes equipment, nutrients, and containers. Additionally, recurring costs such as electricity and nutrients also contribute to the overall expense.
- **Dependency on Utilities:** Due of its heavy reliance on electricity and water, hydroponics is susceptible to interruptions in the water supply or power outages. Crop losses may result from these, which may impact the entire cultivation process.
- **Labor Intensity:** Hydroponics requires additional labour for system monitoring and maintenance even though it eliminates the necessity for weeding and control of pests. This involves pH balancing and routine nutrition changes.
- **Susceptibility to Waterborne Diseases:** Waterborne infections are common in hydroponic systems and are easily spread across plants. Nutrient imbalances, high nutrient levels, and poor sanitation can raise the risk of many infections.
- **Limited Organic Certification:** Synthetic fertilizers with controlled environments are common in hydroponic systems, which might not adhere to the stringent requirements for organic certification. This might be an impediment preventing produce cultivated hydroponically from reaching the market.
- **Limited Environmental Benefits:** Some of the environmental benefits of hydroponics, such as water conservation and reduced pesticide use, may be less pronounced if the system relies heavily on energy-intensive lighting and synthetic nutrients.
- **Potential for Waste Generation:** Contamination of the environment might result from improper disposal of fertilizer solutions or waste water. It's critical to get rid of hydroponic waste products without endangering the environment.

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- **Technical Expertise Required:** Hydroponic farming requires a higher level of technical knowledge and expertise to ensure the proper setup, operation, and maintenance of the system.
- **Limited Scalability:** Large-scale hydroponic operations are often more complex and expensive to manage compared to traditional soil-based farming. This can limit the adoption of hydroponics for commercial agriculture.
- **Debates Over Organic Nature:** Hydroponically grown produce may not be considered fully organic by some consumers due to the use of synthetic nutrients and controlled environmental conditions. This can restrict market demand for hydroponically grown crops.

Conclusion

Overall, hydroponics is a promising agricultural technology that has the potential to help us produce more food with less resources and minimize the environmental impact of agriculture. Nonetheless, it acts as a shield against climate change protecting crops from various stress and enhancing their productivity within the controlled environment. It also extends its aid towards farming community in flood plain areas by providing sustainable method which could prevent affecting land as well as their livelihood thereby strengthening the food security.

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Implementing Integrated Farming Systems to Boost India's Profitability, Employment and Climate Resilience Through Promoting Food and Nutritional Security

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Introduction

Small-scale and marginal farmers, who make up 85% of the total farming community in India, are at the heart of the rural economy. An integrated farming system (IFS) has been identified as a solution to meet the growing demand for food production and to provide income stability and nutritional security, especially for these farmers with limited resources.

The IFS approach involves combining various farm enterprises, including crop cultivation, livestock rearing, aquaculture, poultry farming, sericulture, and agroforestry, to achieve economical and sustainable agricultural output through efficient resource utilization. This integrated system operates by recycling farm and animal waste, with one component's waste serving as inputs for other components. This approach also promotes crop intensification and diversity, resulting in higher yields per unit area. Furthermore, IFS reduces the reliance on harmful agrochemicals for farm productivity and naturally manages insect pests, diseases, and weeds through crop management techniques.

IFS Model Development

The IFS model integrates a variety of complementary agricultural activities, including growing field and horticultural crops, practicing agro forestry, raising livestock, engaging in fisheries, cultivating mushrooms, and beekeeping, in a synergistic manner. This approach ensures that the byproducts of one process are utilized as inputs for other processes, maximizing farm productivity. Field crops are cultivated to produce food, while horticultural and vegetable crops, grown on the same land, yield 2-3 times more energy than cereal crops, ensuring both food security and sustainable income. After harvest, crop residues can be used as animal feed, contributing to milk and goat production. Animal waste can be converted into organic fertilizer or vermicompost, enhancing soil fertility and reducing the need for chemical fertilizers. Additionally, animal waste can be further processed to generate biogas and energy for domestic use. Fish in the system improve soil fertility by increasing the availability of essential nutrients like nitrogen and phosphorus, leading to higher rice yields in integrated farming. When chickens or ducks are raised near ponds, their waste becomes nutrients for the fish, enhancing fish production. This holistic approach, combining crops, fish, and poultry, results in the highest net revenue and land health improvement. By integrating various elements, including vegetable and fruit crops, cultivation costs are reduced, and households receive essential nutrients. Furthermore, the IFS model, encompassing agriculture, dairy, fisheries, horticulture, beekeeping, and mushroom cultivation, generates year-round employment opportunities.

Advantages of IFS

- By consolidating crops and related businesses, IFS enhances productivity per unit area.
- Implementing proper crop rotation, utilizing cover crops, and incorporating organic compost not only improve soil quality and structure but also reduce nutrient losses.
- Effective crop rotation minimizes weed, insect pest, and disease issues.
- The family's labor and land resources in agriculture result in higher net profits.
- Integrated farming, which includes products like eggs, milk, mushrooms, vegetables, honey, and silkworm cocoons, also ensures a steady and dependable income.
- It cuts down the production cost of components by recycling inputs from the by-products of associated enterprises, preventing waste buildup and subsequent pollution.

Constraints

In spite of several benefits, farmers in various parts of the nation are unable to implement IFS systems because of various obstacles. These limitations fall under a variety of headings, including institutional, policy, biophysical and sociocultural, financial, and so forth. The adoption of an integrated crop-animals system in Madhya Pradesh has been hindered by financial constraints, such as high input costs and lack of essential funding, mostly because of the high initial costs associated with setting up an animal shed and buying livestock, among other things. Moreover, biophysical barriers to IFS system adoption included the scarcity of high-quality planting materials, ignorance of novel crops like fodder, and the lack of veterinary services. These factors constituted the main obstacles to the crop-livestock system's adoption in Tamil Nadu's Salem District. Furthermore, farmers in Indonesia are resilient to change and are shown to be laggards in the adoption of new technologies, improved crops, and livestock breeds. These sociocultural restrictions, namely the unique character and attitude of the farmers, are determined to be the key factors in implementing an IFS system. In Southern Karnataka, India, where the study was conducted, about 30% of farmers who belonged to the scheduled caste expressed disapproval towards the adoption of IFS. Therefore, the farmer's attitude and acceptance of integrated farming systems might be effectively transformed by anchoring suitable motivation and encouraging through training and demonstration together with finance facilities and an assured supply of essential quality planting materials. However, insufficient institutional or governmental support exists for the implementation of IFS in the various agro climatic zones of the nation. Farming will affect soil, water, landscape, and biodiversity more than other environmental factors because of its direct relationship to the environment. Therefore, agro-ecological assets must be preserved, ecological balance must be maintained through sustainable use of natural resources, and farmers must be protected against market volatility by means of region- or location-specific policies that offer crop-specific pricing, insurance, and income support.

Conclusion and Way Forward

The article underscores the significance of Integrated Farming Systems (IFS) in efficiently managing farm resources for income generation, environmental protection, and livelihood security in rural areas. Exploiting the synergies among farming components is crucial for improving resource-use efficiency and recycling farm by-products. IFS, relying more on local resources, proves to be both sustainable and profitable, accommodating various crops, livestock, trees, honeybees, etc. This diversity enhances the system's resilience to climate changes, offering a potential approach to mitigate climate change through increased carbon sequestration. Creating awareness and securing government support are essential for widespread adoption of region-specific IFS models.

Several limitations and opportunities were identified in farming system research. Initially, the focus on production outcomes like yield and income enhancement raised the need for future research to explore the relationships between landholding size and livelihoods for farmers and laborers. For instance, while IFS yields higher production, the lower absolute levels of marketable produce raise questions about the sustainability of livelihoods. Small farm families should explore both agricultural and non-agricultural income sources, such as value addition, for sustainable livelihoods. Secondly, limited studies on production types and their associated environmental implications underscored the importance of assessing specific farm sizes, types of enterprises, and recycling methods in IFS to better understand scale-specific relationships between farm size and environmental impacts. Lastly, few studies have considered the comprehensive ecosystem services provided by different types of IFS systems, such as homestead farming, agro forestry-based, and livestock-based. Future research should delve into the well-being of laborers, farmers, and consumers, exploring their interaction with farm size and other social and environmental outcomes.

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Integrated Weed Management strategies in Himachal Pradesh

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Introduction

Integrated weed management (IWM) involves the concept of multiple tactics of weed management, maintenance of weed population below economic injury level and conservation of environmental quality. A successful IWM strategy has the principle of enhancing farmers' profitability, environmental protection and responsiveness to consumer preference.

Description of a Weed

There are numerous definitions of a weed, including:

- a plant out of place and not intentionally sown
- a plant growing where it is not wanted
- a plant whose virtues have not yet been discovered. (R.W.Emerson)
- plants that are competitive, persistent, pernicious, and interfere negatively with human activity (Ross, et. al.) and many others

No matter what definition is used, weeds are planting whose undesirable qualities outweigh their good points, according to man. Our human activities create weed problems since no plant is a "weed" in nature. Though we may try to manipulate nature for our own good, nature is persistent. Through the manipulation process, certain weeds are controlled, while, other more serious weeds may thrive because favorable growing conditions for them also have been meet. Weeds are naturally strong competitors and those weeds that can best compete always tend to dominate. Both humans and nature are involved in plant breeding programs. The main difference between the two programs is that man breeds plants for yield, while nature breeds plants for survival.

Characteristics of weeds

Certain characteristics are associated with and allow the survival of weeds. Weeds posses one or more of the following:

- Abundant seed production
- Rapid population establishment
- Seed dormancy
- Long-term survival of buried seed
- Adaptation for spread
- Presence of vegetative reproductive structures
- Ability to occupy sites disturbed by human activities.

There are approximately 250,000 species of plants worldwide; of those, about 3% or 8000 species behave as weeds. Weeds are troublesome in many ways. Primarily, they reduce crop yield by competing for water, light, soil nutrients, and space. Other problems associated with weeds in agriculture include:

- reduced crop quality by contaminating the commodity
- interference with harvest
- serve as hosts for crop diseases or provide shelter for insects to overwinter;
- limit the choice of crop rotation sequences and cultural practices
- production of chemical substances which are toxic to crop plants (allelopathy), animals, or humans.

Costs of weeds

Weeds are common on all 485 million acres of U.S. cropland and almost one billion acres of range and pasture. Since weeds are so common, people generally do not understand their economic impact on crop losses and control costs. In 1991, the estimated average annual monetary loss caused by weeds with current control strategies in the 46 crops grown in the United States was $4.1 billion. If herbicides were not used, this loss was estimated to be $19.6 billion. Losses in field crops accounted for 82% of this total (Bridges; WSSA, 1992).

Another source estimates that U.S. farmers annually spend $3.6 billion on chemical weed control and $2.6 billion for cultural and other methods of control. The total cost of weeds in the United States could approach $15 to $20 billion dollars (Ashton and Monaco, 1991). Also, weed control and other input costs (e.g., seed, fertilizer, other pesticides, fuel) vary with the crop. For example, in the mid-90s, herbicides for soybeans cost $30/acre or about 47% of the $63/acre in total purchased input. For corn, the cost was $32/acre or about 28% of the $114/acre in total purchased input. And for wheat it was $6 or about 6% of the total $96/acre inputs. Several factors help determine the relative costs of herbicides from one crop to another and include the competitive ability of the crop, the weeds present, the contribution of non-chemical control practices, the tillage method, management decisions, and the value of the crop. (Ross and Lembi, 1999)

Benefits of weeds

Despite the negative impacts of weeds, some plants usually thought of as weeds may actually provide some benefits. Some attributes include:

- Soil stabilization;
- Habitat and feed for wildlife,
- Nectar for bees;
- Aesthetic qualities;
- Add organic matter;
- Provide genetic reservoir;
- Human consumption; and
- Provide employment opportunities.

Weeds have a controversial nature. But to the agriculturist, they are plants that need to be controlled, in an economical and practical way, in order to produce food, feed, and fiber for humans and animals. In this context, the negative impacts of weeds indirectly affect all living beings.

Weeds vary so much in their growth habit and life cycle under different ecosystems and growing seasons that no single method of weed management can provide effective weed control. Continuous use of one method of weed control creates problems of buildup of weeds that are tolerant to that particular method of weed control. Similarly, shift in weed flora from annual grasses to sedges and appearance of resistant biotypes due to continuous use of some herbicides has been reported. Long term strategy to minimize weed problem is through IWM than with weed control. Major components of IWM include:

- Monitoring weeds, shifts in weed flora, appearance of resistant weeds and introduction of new weeds,
- Emphasis on ecological, biological and biotechnological methods of environmental safety, and

- Low cost agronomic strategy for weed management in IWM systems
- Stale seedbed,
- Balanced fertilizer use,
- Higher plant population,
- Intercropping / relay cropping, and
- Use of competitive cultivars,
- Supplement herbicide use at minimum possible rate.

Ecological management

Ecological management (cultural management) aims by attacking ecological weak points of weeds during field operations such as ploughing, water management, crop season, crop rotation, intercropping etc.Ploughing is usually done at optimum soil moisture content by which time the weeds seeds start emerging. Hence emerging weed seedlings are buried or exposed to hot Sun for drying in perennial we eds, ploughing is effective to control emergence whose propagules are formed at relatively shallow position within soil. Intensive puddling is very effective for weed control in lowland rice.

Water management practices are very effective for weed control especially in lowland rice. Continuous land submergence beyond 5cm depth for rice is very effective against several weeds and can substitute for weed control. Lowland rice crop rotation with an upland crop is effective against moisture loving weeds. The population of scirpus maritimus and echinochloa increases with continuous cropping of lowland rice but decline when rice is rotated with and upland crop. Similarly, population of celosia Argentina increases due to continuous growing of short saturated crops such as groundnut but decreases considerably when rotated with tall crops such as sorghum, maize, pearl millet etc.

Biological management:

Biological weed control using insects, pathogens, fish and snails (bio agents) appears to be ideal for reducing the inputs of herbicides. Some promising examples include:

Weed Biocontrol agent

Alternanthera philozeroid Cassida sp.

Salvania molesta Paulinia acuiminata (insect) and *Myrothecium rovidium* (fungus)

Eichhornia crossipes Alternaria eichhornia (pathogen) and *Neochetina bruchi* (insect)

Cyperus rotundus Bactra minima (insect) and *Athespacuta cyperi* (weevil)

Use of Maxican beeitle (Zygograma bicolorata) in Parthenium

Bio herbicides:

Although herbicides are effective for weed control, there has been increasing concern about their safety for food products, their adverse effect on environment and widespread weed resistance to herbicides. These factors along with rising prohibitive costs have provided the impetus to develop alternative weed management strategies. In this contest, biological control has an alternative or supplement weed management appears to play a major role in crop production. Biological approach includes bio control agents such as insects, nematodes, fungi and bacteria as well as plant-based chemicals that exhibit herbicidal properties. A bio-herbicide is a plant pathogen use for weed control through application of its inoculums.

Bio-technology in weed control

The microbial toxins and allelochemicals could be manipulated to produce commercial herbicides. Bioherbicides Collego and Biopolaris are used for controlling grass and broad-leaved weeds in rice. In India, bioherbicides for weed control have not yet developed to the extent of practical application.

Agronomic practices

Agronomic measures necessary for higher yields are at the same time are directed at preventing mass multiplication of weeds.

Stale seed bed

It involves the removal of successive flushes of weeds before sowing a crop. Weeds that germinate after land preparation are destroyed mechanically, manually or chemically. In mechanical or manual method, soil disturbance should be as shallow as possible.

Crop stand

Closure the spacing or higher the seed rate, better the crop can compete with weeds due to its smothering effect on weeds.

Nutrient management

Nutrient application should be timed to prevent weed proliferation and yet to obtain maximum benefit from the applied nutrient.

Intercropping and Relay cropping

Intercropping upland rice with groundnut, soybean, or green gram minimizes weed density leading to yield advantage. A pulse crop is usually broadcast as relay crop into standing rice crop 10-15 days before harvest. As soon as rice crop is harvested the pulse crop cover the field in dry season and suppress the weed growth.

Cultivars

High yielding cultivars are less competitive against weeds than traditional cultivars. For rainfed areas, heavy tillering varieties of medium stature may be better suited than semi-dwarf varieties.

Herbicides

Non chemical methods of weed control when integrated with one manual weeding are as effective as standard rice herbicides at different ecosystems throughout the country.

Integrated weed management in different crops

- Study on IWM under Palampur conditions has shown that intercropping of soybean with maize (1:1), 75000 maize plants per hectare with 25% higher than recommended fertilizer and application of Lasso @3 l/ha or Pendimethalin 1.5 kg/ha as pre-emergence gave effective control of weeds. In case chemicals are not available, substitute with one weeding within 30 days of sowing.
- Integration of adequate density of crop plants by drilling or line planting at proper row spacing, timely fertilizer application and water management practices can reduce the crop weed competition in rice.
- Mechanical/physical weed control: Use of cono and rotary weeder in rice
- Growing wheat in closer rows with 15 cm spacing or cross row sowing at 22 cm with half of the seed and fertilizer distributed ion each direction resulted in decreased number of *Phalaris minor* and wild oat plants which can be controlled using 0.75kg/ha Iso prouron as post emergence.
- Stale seed bed preparation before the sowing of Kharif crops.

Conclusion

A framework for Integrated Weed Management (IWM) in wheat should consider the whole life cycle from emergence to seed production. An IWM strategy should aim at minimizing one or more of the following: weed establishment, weed competition, and seed production/production of vegetative organs. As highlighted in this review a number of weed management tools are available to the farmers, but most of them are not as effective or reliable as herbicides (Lutman et al., 2013) and need to be combined into a strategy and IWM has therefore been referred to as the "many little hammers" (Liebman and Gallandt, 1997). Some weed management options like mechanical weeding may be more expensive than chemical control, which needs to be balanced against the potential long-term benefits of more sustainable IWM strategies. Moreover, IWM is more knowledge intensive than chemical weed control and will require understanding of the biological processes in the field (Swanton and Weise, 1991), and unfortunately, IWM has not received much attention in the scientific literature where papers on "weed control" outnumber the one on "IWM" by 14 to 1 (Harker and O'Donovan, 2013).

Future IWM strategies need to be context specific considering the different cropping conditions in the different parts of the world. IWM tools that are suitable for more humid conditions like cover crops may not be suitable for more dry conditions where water conservation is of high priority. Adopting IWM will often lead to a reduction in herbicide use (Bürger et al., 2012; Chikowo et al., 2009) but from a point view of weed management sustainability, preventing weed resistance and weed population shifts, a reduced reliance on herbicides is more important than a reduction in the amount of herbicide applied. From an environmental point of view a reduction in herbicide use may be beneficial, but very few studies have explored this aspect. Deytieux et al. (2012) using a life cycle assessment approach concluded that most environmental indicators were improved in IWM-based systems when expressed per unit cultivated area; however, the ranking changed when evaluated per unit harvested agricultural goods reflecting a lower productivity of some IWM systems.A number of genes have been employed for the generation of genetically-modified crops possessing tolerance to herbicides in an effort promote crop growth and discourage the growth of competing plants such as weeds. Herbicide-resistant genes are also invaluable for use as selectable markers in the genetic transformation of plants. The majority of herbicide-resistant genes are derived from soil bacteria such as Agrobacterium and Streptomyces, organisms which have never been utilized as ingredients in products for human consumption. With respect to the use of plant-derived genes for herbicide tolerance, attention may be paid in order to facilitate public awareness and acceptance of the technologies involved.

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Journey to Protein Structure Prediction using A.I.

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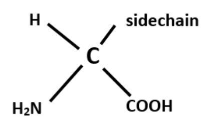
Introduction

The protein structure prediction problem is the question of how a protein's sequence of amino acids results in its fully folded 3D structure. protein structures provide a better understanding of the molecular mechanisms of a protein and in doing so offer insights into how the protein works and how its modulation can help human interest as proteins are one of essential macromolecules working as structural support, transporters, enzymes, gene regulators, receptors etc. in living beings, we know that amino acids are building blocks of proteins, every amino acid contains an amine group, the carboxylic acid and a tetrahedral carbon and side chains which dictates the properties of the amino acids, journey of a protein starts from DNA as the flow of information is from DNA to protein, nucleotide sequence of an gene gets transcribed to RNA which after being processed is used by ribosomes to synthesize amino acid chains, ribosomes reads three bases of messenger RNA to add one amino acid to the chain forming a linear heteropolymer referred to as the primary sequence of the protein which determines the structure of the protein, and structure determines the function of protein. All proteins are composed of same 20 amino acids in different composition and sequence. The part what path does primary sequence follows to form 3D structure remains unknown from last 50 years.

3D Structure of Proteins

The primary structure of the proteins is established by peptide bonds and covalent bond's further structure take place because of non-covalent interaction. Secondary structure is driven by the hydrogen bonding, tertiary structure is by virtue of electrostatic interactions; hydrogen bonds, hydrophobic interactions and van der waals forces or simply we can say interaction between sidechains, sidechains and peptidebackbones, sidechains and water.



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All the interactions stated above for formation of secondary and tertiary structure takes place within amino acids of single protein molecule but when these interactions take place between different protein molecules it gives rise to the quaternary structure. Physical chemists, physicists and computational chemists have tried to understand how we can predict the folding structure from primary sequences.

Name	Interaction	Bond (kcal/mol)
Covalent	Shared electrons	50-100
Ionic	Attraction of opposite charges	Very variable
Hydrogen bond	Interaction of H on N, O, S with electron pair on O, N, S	3-7
Hydrophobic	Interaction of non-polar groups exclusion of water.	1-2
Van der waals	Interaction between weakly polarized bonds	1

Protein Folding

The polypeptide chain of proteins with variable sequence of amino acids makes proteins a heteropolymer that is not constituted of a repeating monomer, the different amino acids with different sidechains attached to them some of which being hydrophobic and others being hydrophilic gives rise to interactions within the polymer causing it fold in a three-dimensional structure and the process whereby you go from the extended primary sequence to the folded structure is called protein folding. In 1944 the physicist Erwin Schrodinger suggested that living systems obeyed all laws of physics and should not be viewed as exceptional but instead reflected the statistical nature of these laws (Whitford, 2013). A major milestone in protein science was the thermodynamic hypothesis of Christian Anfinsen and colleagues he postulated that the native structure of a protein is the thermodynamically stable structure; it depends only on the amino acid sequence and on the conditions of solution, and not on the kinetic folding route (Dill *et al*., 2008). Since then, various aspects of protein folding mechanism have been discovered which appears as a jigsaw. The way Proteins function I would agree with the statement; proteins should be viewed as flexible molecules that can take up a whole ensemble of different structural conformations (Van *et al*., 2023). Varius surrounding factors such as temperature, pH, salt

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concentration etc. affect the structure of protein making protein folding a random probability distribution or pattern which may be analyzed statistically but may not be predicted precisely. Usually, proteins are present either in their native state (folded state) or unfolded state because of the surrounding factors they continuously fold, unfold and re-fold maintaining adynamic equilibrium.

Thermodynamic Aspects of Folding

In thermodynamics it is assumed that every system will eventually reach a state where there is no net flow of energy or molecules between different parts of the system. To understand it in respect to protein folding *in vivo* (room temperature and neutral pH) proteins are in thermodynamically stable form (native state) since simple environment of proteins are always changing, proteins are found to be in Equilibrium that is individual molecules can still (stochastically) switch between the folded and the unfolded state, but the total number of molecules in each state remains constant. (Van *et al*., 2023). Like any thermodynamic system protein folding also have two free energy minima separated by a barrier, the difference between free energy (the free energy of the folded state is lower that the free energy of the unfolded state.) of both states determine the rate of transmission from one state to another which can be determined by

$$\mathbf{F = H - T\,S}$$

where H is the enthalpy (internal energy in the system)

T is the temperature in Kelvin

S is the entropy (quantification of the amount of conformational freedom of the system).

Protein Folding Problem

In 1969 Cyrus Levinthal, a molecular biologist, estimated that a protein with 100 amino acids, where each peptide bond in between two amino acids has two possible torsion angles, and each of these angles can assume three different values. The protein then has $3^{99}\times 2 \approx 2.9 \times 10^{94}$ possible conformations, even if each conformation takes one picosecond to go through the confirmation it will take more time then the age of universe (Levinthal's Paradox), and yet, proteins achieve the correct conformation in a fraction of a second (Al-Janabi, 2022) therefore it can be said that protein folds under some kind of pathways leaving us with questions revolving around its stable state and ways to reach their, *Science* magazine framed the problem this way: "Can we predict how proteins will fold?

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Out of a near infinitude of possible ways to fold, a protein picks one in just tens of microseconds. The same task takes 30 years of computer time" (Dill *et al.*, 2008).

Conventional Ways of Structure Determination

At the beginning of 2004 over 22 000 protein structures (22348) were deposited in the Protein Data Bank. Over 86 percent of all experimentally derived structures (~19400) were the result of crystallographic studies, with most of the remaining structures solved using nuclear magnetic resonance (NMR) spectroscopy. Slowly a third technique, cryoelectron microscopy (cryo-EM) is gaining ground on the established techniques and is proving particularly suitable for asymmetric macromolecular systems (Whitford, 2013)

Deepmind and Alphafold

Using x-ray crystallography, nuclear magnetic resonance spectroscopy or cryogenic electron microscopy for prediction of protein structure is time consuming and majorly based on trial-and-error approach one of the main reasons for which was given by Cyrus Levinthal as stated above, because of which computational procedures are developed for the prediction of 3D protein structures. In 1994 Krzysztof Fidelis (University of California CA, USA) and John Moult (University of Maryland, MD, USA) founded the Critical Assessment of Structure Prediction (CASP) which according to them is an experiment to solve the half a decade old problem of protein folding, from 1994 CASP takes place in every two years where various teams participates with their computational models for prediction of protein structure, at CASP predictor groups with protein sequences whose structures have been solved but have not yet been made publicly available. To assess the accuracy of predictions made by competitors. The Global Distance Test (GDT) is the main metric used to assess the success of the computational models and ranges from 0 to 100. This can be thought of as the percentage of amino acid residues that are within a certain distance from the correct position, where the experimental structures are used as the 'ground truth' (Al-Janabi, 2022).

Deep Mind has developed an A.I. model that takes us one step closer to predicting the 3D shape of a protein from only its one-dimensional amino acid sequence. without the need for tedious and costly lab analysis. In 2020 Google's Deep Mind introduced Alpha Fold 2.0, which achieved an average GDT of 90 at CASP14, the development of computational methods to predict three-dimensional (3D) protein structures from the protein sequence has proceeded along two complementary paths that focus on either the physical interactions or the evolutionary history (Jumper et al., 2021) physical interactions as discussed above all the covalent and non-covalent forces in thermodynamic and kinetic stimulations although various interactions are unknown and not been included in alpha fold 2.0 on the other hand evolutionary approach is based on the on bioinformatic analysis of the evolutionary history of proteins that is various mutants of similar proteins the makers of alpha fold combined the methods for Alphafold 2.0 it uses the structures available in public domain by world protein banks and data gathered by structural biologists to make predictions. AlphaFold structures had a median backbone accuracy of 0.96 År.m.s.d.95 (Cα root-mean-square deviation at 95% residue coverage) (95% confidence interval = 0.85–1.16 Å) (Jumper et al., 2021).

Conclusion

No doubt advance in protein structure prediction technology will benefit all the fields of biological sciences and agriculture as well, various aspects of living organisms are either beneficial or non-beneficial to us and these life processes can be altered with the help of knowledge obtained from the technologies like alpha fold. Various diseases like sickle cell anemia are nothing but the structural deformity in proteins, various medicines are designed on the basis of the protein structures, the author believes that there is unseen huge application of this technology in genetics, entomology and plant pathology for development of biotic stress resistant cultivars. also, various knowledge gaps for example the ways in which plant individuals respond to biotic and abiotic stresses can allow us to set more defined breeding programs on the basis of biochemical characters which are strongly correlated with stress resistant qualities of plants.

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Major Insect Pests of Sugarcane (*Saccharum officinarum*) Crop and Their Integrated Management Approaches

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Abstract:

Sugarcane has a fair variety of insect pests that flourish on it, and on average, these insect pests cause a 15-20% loss in yield, in addition to a decrease in produce quality (Majumder, 2020). It is accepted that half of these total insects are of new world origin, while the other half are of old world or oriental origin. In other words, approximately 650 insects visit sugarcane in the old world, to which India belongs. A larva enters the cane by a small hole in the epidermal tissues (leaf, leaf sheath, and stalk) and feeds within the tissues. Sugarcane borer infestations cause direct injury. Sugarcane borer infestations cause direct injuries owing to galleries produced along the sugarcane stems, which might lower yield and indirectly allow fungal colonisation (Pannuti *et al.*, 2013). Furthermore, losses are exacerbated by lower sugar content and contamination of sugarcane juice, which impedes fermentation in the ethanol manufacturing process (Rossato Junior *et al.*, 2013).

Keywords: *Saccharum officinarum*, Insect-pests, Borers, Management approaches

Introduction

Sugarcane, *Saccharum officinarum*, has grown to be one of India's most important crops, giving thousands of direct, indirect, temporary, and permanent jobs. Sugarcane attracts a variety of insect pests, which cause a production loss of 15-20% each year on average, as well as a decline in output quality (Majumder, 2020). Box (1953) conducted a global census of sugarcane-feeding insects, identifying 1300 species that visit sugarcane on a regular basis. However, not all of these insects are found in a single country or continent; each country's insect fauna has only a portion of them. It is accepted that half of these total insects are of new world origin, while the other half are of old world or oriental origin. In other words, approximately 650 insects visit sugarcane in the old world, to which India belongs. So far, around 220 insects have been identified as sugarcane pests in India (David *et al*., 1986). Borer larvae cause harm to the sugarcane crop. Except for the rare foray outside in search of a new feeding place, a larva spends most of its time beneath the protective cover of the cane tissues. Thirteen species of borers have been identified as sugarcane pests in India. Only nine of these are regarded important and have a significant economic impact. These nine species are from six Lepidoptera genera (five Pyralids), namely *Acigona* (1), *Chilo* (4), *Emmalocera* (1), *Raphimetopus* (1), *Scirpophaga* (1), and (one Noctuid) *Sesamia* (1) (Majumder, 2020). Among the limiting factor for good performance and crop yield of sugarcane in India are sugarcane borers such as early shoot borer, *Chilo infuscatellus* Snellen (Lepidoptera: Crambidae); Green borer, *Raphimetopus ablutella* (Zeller) (Lepidoptera: Pyralidae); Pink borer, *Seasmia inferens* (Walker) (Lepidoptera: Noctuidae); Root borer, *Emmalocera depressella* (Swinhoe) (Lepidoptera: Pyralidae); Top borer, *Scirpophaga excerptalis* (Walker) (Lepidoptera: Crambidae); Plassey borer, *Chilo tumidicostalis* (Hampson) (Lepidoptera: Crambidae); Stalk borer, *Chilo auricilius* Dudgeon (Lepidoptera: Crambidae); Internode borer; *Chilo saccharphagus indicus* (Kapur) (Lepidoptera: Crambidae); Gurdaspur borer, *Acigona steniellus* (Hampson) and maize or sorghum borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) (Majumder; 2020 and Sallam, 2006). Sugarcane borer infestations cause direct injuries owing to galleries produced along the sugarcane stems, which might lower yield and indirectly allow fungal colonisation (Pannuti *et al*., 2013). Furthermore, losses are exacerbated by lower sugar content and contamination of sugarcane juice, which impedes fermentation in the ethanol manufacturing process (Rossato Junior *et al*., 2013). The damage could cause apical meristem mortality, aerial root growth, lateral sprouting, and biomass loss (Cheavegatti Ginotto *et al*., 2011; Vargas *et al*., 2015). Chemical treatment of sugarcane borers with synthetic insecticides is hampered by the larvae's cryptic feeding habit inside sugarcane stems for five to seven instars. Infestations of sugarcane borers continue to be a problem for sugarcane productivity. However, biological management using larval-pupal parasitoids has been successful for this group of insects (Chichera *et al*., 2012, Dinardo-Miranda *et al*., 2014, Parra, 2014, and Vargas *et al*., 2015).

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Top borer, *Scripophaga excerptalis* (Walker)

It is a major pest of sugarcane in India, particularly in the subtropical area, where it is recognised as the most serious entomological concern in sugarcane farming (Majumder, 2020). The top borer pupa is exceedingly fragile, slender, and cylindrical. The pupa's body wall (cuticle) is exceedingly thin and translucent. The pupal colour varies as it matures. Male pupas develop ochrous, but female pupas become primarily white. Female pupas' anal ends turn white and then orange, whilst male pupas retain their body colour.

Stalk borer, *Chilo auricilius* Dudgeon

It is a sugarcane borer that causes considerable damage to the mature cane stalk. This is also known as the "Tarai borer" because to its predominance in the Tarai region (a damp and cold subtropical belt). A newly produced pupa is yellowish-white or creamy yellow in appearance, and with time, the pupa's colour changes to light brown. The pupa is small and tiny. If a pupa is present in the dark decaying stalk tissues, it turns exceedingly dark. On the 9th segment of a male pupa, the genital region appears as a small depressed furrow between two broadly elevated lobes. A lengthy triangular area develops from the anal area up to the base of the 8^{th} segment in female pupas, and the genital area is marked by a noticeable dark coloured depression (Majumder, 2020).

Pink borer, *Sesamia inferens* (Walker)

It is a polyphagous pest that infects a variety of crops such as rice, wheat, maize, sorghum, sugarcane, finger millet, and others. The pink borer is active all year because one or more host crops are available. It is commonly known as the pink borer due to the larva's distinctive pale pink body colour or raw flesh colour, and it can also live in sugarcane habitat. Pink borer pupas have many uneven rows of characteristic depressions (pits) on each abdominal segmental body. The anal projections (cremaster) are smaller and darker brown to black in hue. In rice pink borer, the upper portion of the pupal body is mostly covered with white substances, while sugarcane pink borer is infrequently found (Majumder, 2020). The white powdery stuff may occasionally reach the vaginal area. The male pupa has two noticeable elevated lobes with a centre depression on the 9^{th} segmental. Female pupas are larger and have multiple concentric light triangular patterns on the 8^{th} and 9^{th} segments.

Root Borer, *Emmalocera depressella* (Swinhoe)

E. depressella infestation causes "dead hearts" and general yellowing of the leaves, as well as poor tillering in mature plants (Bhatt *et al*., 1996). The ideal temperature for this insect pest is 30-35°C, with a high relative humidity. Extremely high or low temperatures, when combined with low humidity, are adverse to insect development (Sardana, 1997).Larvae usually make tunnel inside the base of the stalk or in the stubble. Last instar larvae hibernate in sugarcane stubble from the middle of November to the first week of December. In the majority of cases, only one larva may be found hibernating per plant (Kundu et al., 1994). Females lay eggs singly, mostly on the underside of the leaves. Newly hatched creep downhill towards the plant's base through soil fissures and burrows into the stalk's base (Kundu *et al*., 1994), and sandy, sandy loam soils that receive frequent irrigation have greater infection rates.

Shoot Borer, *Chilo infuscatellus* Snellen

Because the immature larvae of Chilo infuscatellus feed on the outer leaves of sugarcane plants, the crop is harmed during the shoot stage. The third instar larvae then burrow into the stem (Easwaramoorthy and Nandagopal, 1986). The borer burrows downward via young shoots. This causes the upper half of the central leaf whorl to be detached, which dries out and generates "dead hearts" in shoots that are one to two months old. These are easily removed, and the decaying component of the straw-colored dead heart emits an awful odour. A number of bore holes near the foot of the shot, just above ground level. An early attack kills the mother shoot completely, whereas a late strike produces considerable tillering. The caterpillar is brownish in colour with a white body and five violet stripes on the dorsal side. Crochets on the proleg are semicircular or crescentic. Every caterpillar moves and shoots at different shoots. The larval stage pupates within the stem and lasts about 35 days. The pupal phase lasts 10 days and the pupa is light brown in hue. The adult moth has pale greyish brown wings and whitish hind wings. Darker patterns can be found on the forewings, particularly around the outer margin.

Sugarcane leaf hopper, *Pyrilla perpusilla* (Walker)

Pyrilla is the most damaging pest that consumes sugarcane leaf. Adults and nymphs are both extremely energetic, leaping from leaf to leaf at the slightest disturbance. They absorb the leaf's cell sap and produce honeydew, which attracts the black fungus. The feeding turns the leaves yellow, giving them a scorched, withered appearance covered in black crust. As a result, photosynthesis suffers. High temperatures (26-30°C), high humidity (75-80%), irregular dry spells, and wind movement all contribute to the rapid accumulation of pyrilla. A dense and lush crop, an excess of nitrogen supplied, waterlogging, cane lodging, and cultivars with broad, succulent leaves are all factors that promote the formation of pyrillas.

Pyrilla is estimated to be responsible for approximately 28% of cane yield losses, with a 1.6% unit loss in sugar. The female bug sheds her wings and lays greenish yellow eggs in clusters, mainly on the underside of leaves and between the stem and the detached leaf sheaths. The eggs are covered in white, waxy, cottony threads. In about a week, a cluster of ten to fifteen eggs will hatch. The nymphs feed on plant sap and go through two unique anal procedures.

Integrated Approaches for Pest management:-

- The collection of egg masses and also the infested portions of plants may be reduced the infestation level of all pests at brood emergence period.
- Reduction of incidence is accomplished by burning trash, eliminating plant residues, and eliminating "water shoots" in ratoon crops.
- Earthing up in the month of May and June and application of fertilizers at the pre-monsoon season is a very good for control of early shoot borer.
- To avoid the peak oviposition period of insect pests early planting is the best strategy.
- Early-stage mulching with cane waste has also been shown to decrease occurrence and help in moisture conservation.
- Taking off and destroying the infected tillers as close to the ground as possible is a best mechanical control for all pests.
- Applying 25 kg/ha of Cartap hydrochloride granules to the soil during planting, followed by other application on the 45th day for crops that were planted later.
- In the first month of planting, the egg parasitoid *Trichogramma chilonis* is released inundatively at the rate of 50,000/ha, at every 7–10 days interval.
- Release of pre-pupal pararsitoid of top borer *Isotima javensis* and egg parasitoid of all borers *Trichogramma japonicum* parasites is very effective for the incidence of insects at egg stage.

- After harvest, burning and destroying trash (detrash) helps in eliminating *Pyrilla perpusilla* egg masses.
- Eliminating grows from the stubble once in month of April may help in decreasing the accumulation of pests.
- Field flooding decreased the severity of root borer, *Emmalocera depressella* infestation.
- Infestation can be decreased by intercropping cowpea with sugarcane. It was discovered that other crops, like black and green grams, decreased infestation.
- For the management of sugarcane leaf hopper *Pyrilla perpusilla,* release of the lepidopteran ecto-parasitoid *Epiricania melanoleuca* @ 4000-5000 cocoons or @ 4-6 lakh eggs/ha and checks its multiplication.
- In case of severe infestation without the occurrence of the ectoparasitoid, spraying of chlorpyriphos @ 2ml/lit. or phosphamidon@0.5ml/lit or dimethoate 2ml/lit. is quite effective.
- Effective insecticide against *E. depressella* is Regent® (Fipronil) 0.3 (granular formulation) at 75 g/ha.
- Application of Carbofuran 3-G @ 1.5 kg/ha is suitable for the control of stalk borer, *Chilo auricilius* infestation.

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Meta-Analysis in Summarizing Research Results

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Introduction

Research involves the creation of novel knowledge, while meta-research entails the consolidation of a vast body of existing scientific knowledge to enhance the practical application of scientific principles and their effects. Social science encompasses academic disciplines focused on studying society and the interactions among individuals within it. Agricultural extension is a fundamental field within social science. Social science research primarily addresses societal issues, offering insights into how society perceives science and innovation and how these impact people's lives. Meta-analysis is a statistical technique used to combine the results of multiple scientific studies, enabling the creation of easily interpretable aggregate measures. Meta-analysis also aids governments in formulating and implementing policies to achieve specific objectives. One significant challenge in social science is policy formulation, which cannot rely solely on the findings of individual studies due to their limited scope. Thus, meta-analysis is a valuable tool for advancing society by improving the implementation of programs and projects.

The results of meta-analysis are a reliable source of evidence that enhances the precision of effect estimates, addresses questions not addressed by individual studies, resolves controversies stemming from apparently conflicting studies, and more. Since extension education is an applied social science focused on disseminating programs to grassroots levels, meta-analysis takes it a step further to enhance progress positively.

Concept of Meta-Analysis

Meta Analysis was first put forth by Gene Glass in 1976 and defined as “a statistical synthesis method that provides the opportunity to view the whole picture in a research context by combing and analyzing the quantitative results of many empirical studies”. A Meta-Analysis is a

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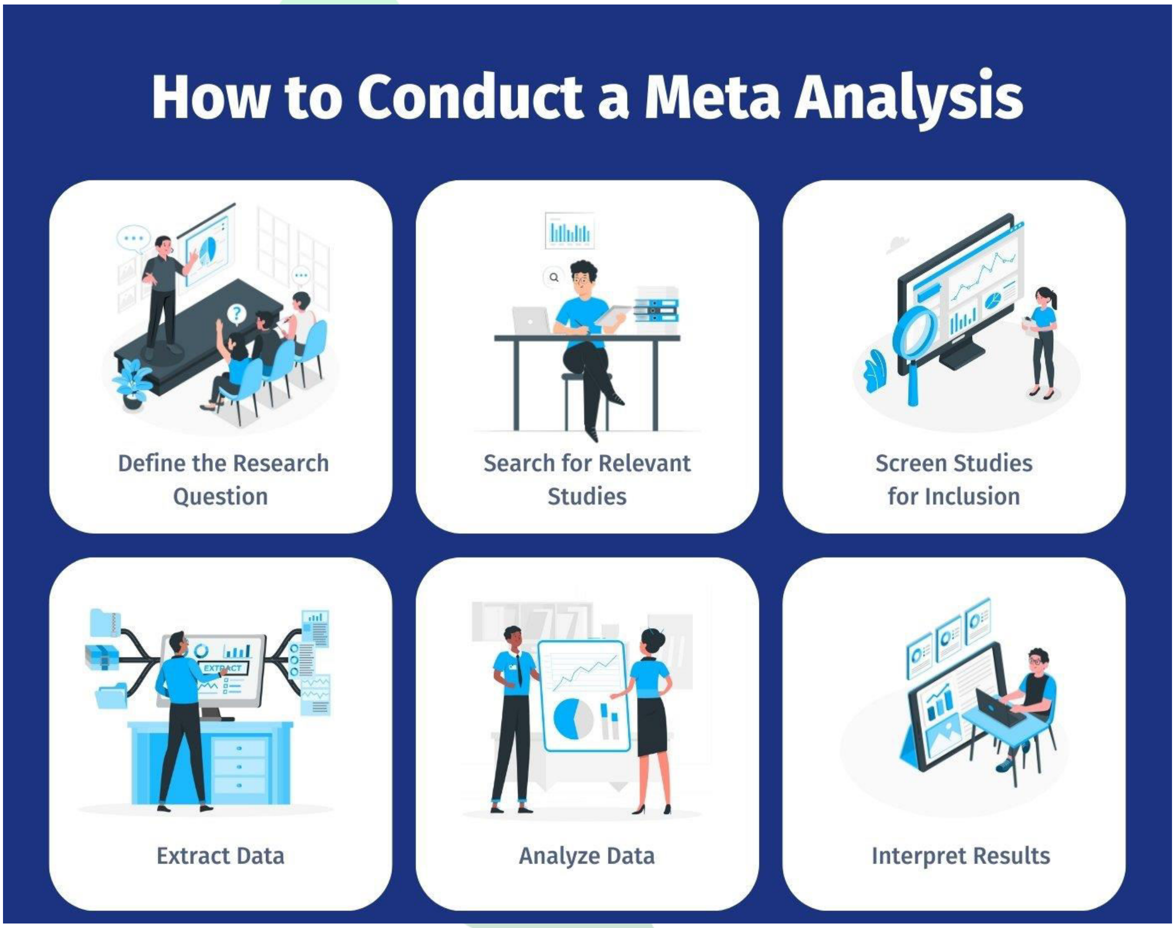
valid, objective, statistical and scientific method of analyzing and combining different results. It is also known as overview synthesis, summarizing analysis, quantitative synthesis and so on and so forth.

Objectives of Meta-Analysis

The main objectives of meta-analysis include consolidating and summarizing findings from various individual studies, scrutinizing variations in results across studies, enhancing the accuracy of effect estimation, investigating and delving deeper into a particular matter, recognizing gaps in the available evidence, and formulating new hypotheses for future research.



Why Meta analysis is important??

- Derive the pooled estimate
- Improves the precision of estimates of effect
- Generate new hypothesis
- Try to settle the controversies from apparently conflicting studies
- Answers the questions not posed by individual studies and gives the summary effect

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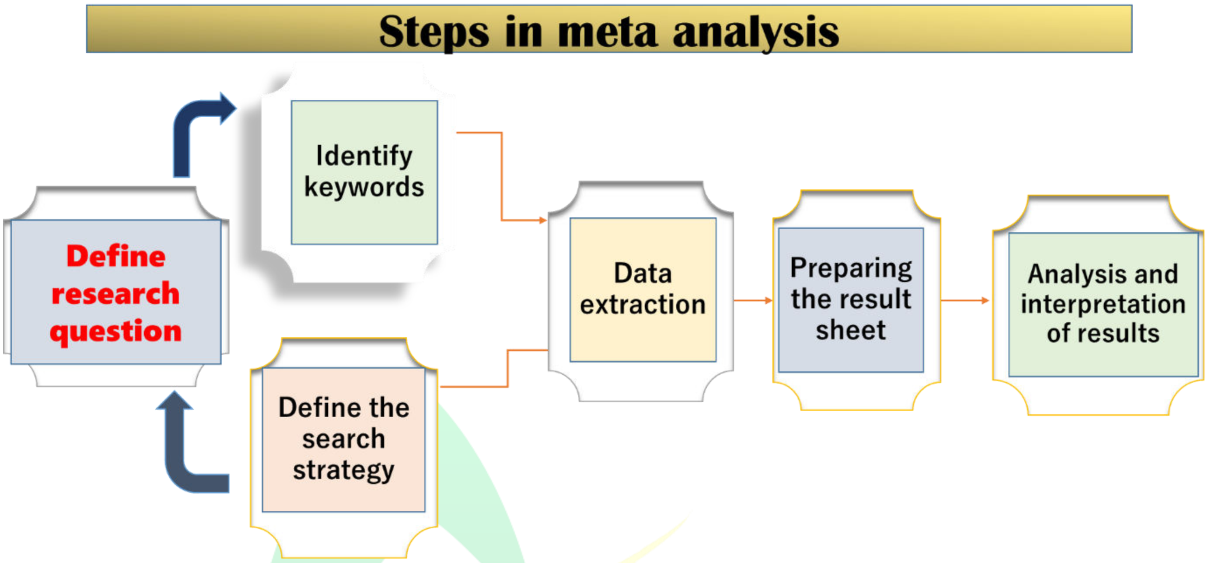

Advantages of Meta-Analysis:

- Meta-Analysis helps to combine studies with small samples and aggregating them gives higher statistical power to the combined results.
- External validity: the results can be generalized to a larger population and can be used in policy formulation and inconsistency of results across studies can be quantified and analyzed
- Hypothesis testing can be employed on summary estimates.
- Enhanced precision and accuracy of estimates result from using more data.
- Moderators can be introduced to elucidate variations between studies.
- The presence of publication bias can be explored.

Limitations of Meta-Analysis:

- Excessive focus on individual effects can hinder the ability to draw valid conclusions due to publication bias.
- Neglects qualitative disparities and the quality of studies.
- Overemphasis on individual effects can be problematic.
- Simpson's paradox, often referred to as the "apples and oranges criticism."
- Challenges in drawing valid conclusions due to publication bias.
- Subjective in coding the effect size.
- Dependence on the availability of statistical software for meta-analysis.
- Fails to account for qualitative distinctions and the quality of studies.

- Limited coverage and the potential for improper blending of studies.

Conclusion:

In order to take the social science research to a long way in terms of its validity and utility, Meta-Analysis would play a pivotal role in achieving it. With due diligence it can solve insurmountable scientific and social problems and also try to attain extra mile to ace the progress on the bright side**.** Meta-Analysis is a useful tool in social science research to summarize the results of several studies, which increases the statistical power of the estimate. The gap in research supporting evidence-based policy can be rectified by employing Meta-Analysis while giving thoughtful attention to developmental concerns. The awareness and discerning observations of researchers can assist social science research in furnishing statistical proof that policymakers can use to undertake corrective measures for more effective policy implementation in society

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Microplastic Menace: The Ecological Impacts on Crop and Soil Health

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Introduction

Plastic pollution has always been a widespread issue of concern for agriculture. The issues multiplied significantly when microplastic comes into being. Microplastic refers to plastic particles ranging from 1µm to 5mm in size which occurs through degradation of primary plastic by biotic or abiotic reasons. Smaller particles have more potential in generating toxicity in the soil and disrupt the microbial biome. These particles have also infiltrated our aquatic bodies and food supply in huge extent [1]. The sources of these microplastic includes mulching plastic, plastic wares used in agriculture, films, packaging materials, irrigation tubing, pesticide containers etc which eventually breaks down into micro pieces [2]. Hence one of the primary objectives in enhancing soil health and crop production should be the concerned endeavour to diminish the presence of microplastics.

Fate of Microplastic in soil

The unbridled increase of plastic pollution is adversely affecting the physio-biochemical properties of the soil which includes enzymatic activities, soil structure, microbial activities and plant growth [4]. Ramos et al. (2015) found that roughly 10% of agricultural lands contains residues of plastic films. Due to their extended life span, plastics persists enduringly, seldom undergoing total decomposition, while bioturbation process transpires. It has been found that microplastics are responsible for reduction of infiltration rate and water holding capacity of the soil which ultimately causes disruption in soil nutrition cycle and micro-biome [5].

Interaction with Soil Organisms

One of the most troublesome effects of microplastics is the disarray of the soil microbes, where beneficial soil microbes faced challenges due to the changes in the soil structure and chemical properties which posed a adverse and detrimental effect on soil health [4]. It was found that after the instigation of increasing microplastic levels, certain

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populations of worms and microarthopods decreased, which led to poor nutrient cycling in the soil[6]. The microplastics also affect the microbial metabolism which shifts the functions of particular microbes in the soil. It was also noticed that microplastics may change the gene expression of the soil microbes, increase of Reactive oxygen species (ROS) , increased biofilm production and increased colonies of pathogenic microorganisms(7).

Repercussions on Crop Health

Microplastic showed many adverse effects on the plant's growth such as, closing of pores in roots and seeds which disrupts nutrient and water uptake mechanisms simulating a drought condition [8]. It also showed modifications and hormonal imbalances, reduction in the content of chlorophyll and reduction in photosynthesis rate.[8] As the crop plants were obtained from lands containing significant amounts of microplastic, the grains or vegetables showed traces of microplastic which is very troublesome for Human health. Thus, it is advisable to limit the use of plastic in the agricultural field or properly discarding the plastic wastes.

Conclusion

The widespread problem of plastic pollution, specifically the rise of microplastics, presents a significant danger to both agriculture and the health of ecosystems. Various sources of microplastics in agriculture, such as plastic used for mulching, packaging materials, and irrigation tubing, contribute to the deterioration of soil quality and disrupt the delicate balance of microbial communities. The continuous presence of microplastics has a detrimental effect on soil properties, enzymatic activities, and the growth of plants, resulting in a series of negative consequences for crop health and subsequently, human well-being. The destiny of microplastics in soil is characterized by their persistent nature, as only a small portion undergoes decomposition. These particles hinder the nutrient cycles in soil, reduce the rate of water infiltration, and have a negative impact on the soil's ability to hold water. This disruption also extends to the interaction with soil organisms, particularly beneficial microbes and invertebrates, leading to a decline in nutrient cycling and changes in microbial metabolism. The effects on crop health are evident, as microplastics cause physiological disruptions in plants, including hormonal imbalances, reduced chlorophyll content, and decreased rates of photosynthesis. Moreover, the infiltration of microplastics into the food supply raises concerns about potential health risks for humans who consume crops grown in contaminated soils. Therefore, it is crucial to address this issue by implementing measures to reduce the use of plastic in agriculture and adopting proper waste disposal practices. Ultimately, mitigating the presence of microplastics in the agricultural ecosystem is essential for preserving soil health, sustaining crop production, and safeguarding human well-being.

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Millets: Rediscovering Ancient Grains for Modern Health

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Imagine a small, tiny grain that fulfils all nutritional requirements of your body, promotes health and even contributes to sustainable agriculture. What if I told you that this grain exists in India. However, it has been neglected for an extended period. Get ready to discover the extraordinary potential of millets—an ancient grain making a comeback in the modern diet.

Millets possess an extensive historical background that traces its origins to ancient eras. The earliest evidence of people cultivating millets were discovered in the Indus Civilization around 3000 BC. Millets have 6000 varieties found across the world. Among them around 2600 BC, the cultivation of the little millet marked the beginning, followed by the cultivation of other varieties such as foxtail millet, sorghum, ragi, kodo millet and bajra. These grains are supposed to be among the first cereal crops used for domestic purposes.

As time passed, the cultivation and utilization of millets spread all over the world. Millets adaptability to various climates and their ability to survive in harsh conditions popularize among the people. Today, millets are cultivated in 131 countries, marking their global prevalence. Across Asia and Africa, millets have remained a traditional food source for around 590 million people.

So basically, millets are plants that belong to the Poaceae (Gramineae) family. Millets are the small seeded grasses that called as nutri-cereals due to their nutritional content. They also referred as the smart food because of their sustainability and environment-friendly nature.

Benefits of millets

Millets offer several extraordinary benefits, such as they offer rich protein, fiber and mineral content, including essential elements like calcium, phosphorus and iron. Millets require minimal water, making them suitable crop for dryland regions and a resilient choice during drought conditions. Additionally, millets serve as valuable fodder and feed for

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livestock. Millet plants can be used in biofuel production, providing an easier-to-process alternative to ethanol. Various millet varieties are used in beer production, contributing to the brewing industry.

Furthermore, millets are an environmentally sustainable crop due to their shorter life cycle, typically ranging from 2 to 4 months depending on the millet variety. They can be cultivated with Limited dependency on fertilizers and pesticides, making organic cultivation feasible. Additionally, millets have a relatively low water requirement, typically around 400 mm, further emphasizing their eco-friendly nature.

Health benefits of millets

Millets offer several health benefits, making them valuable additions to diet of an individual. Millets are tiny grains packed with essential nutrients, including vitamins (especially B-complex vitamins), minerals like iron, calcium and phosphorus of which contribute to overall health. Additionally, millets are rich in dietary fiber, which improves digestion and help in weight loss. Their low glycemic index helps prevent diabetes and blood sugar spikes. Millets have low cholesterol properties are good for heart and cardiovascular health and the antioxidants they contain reduce the risk of heart diseases. Moreover, millets are naturally designated as gluten-free, making them an excellent alternative for person who's with gluten sensitivity or celiac disease.

Types of millets

Millets are classified according to their cultivation area in the countries which mainly two types: major millets and minor millets. The millets which are widely grown in the world is called major millets and millets which have less acreage of area is called as minor millets.

Third category is called pseudo millets or pseudo cereals. The grain which have same nutritional property but does not belong to the Poaceae family is called pseudo millets.

Major millets

Major Millets play a crucial role in global agriculture, contributing significantly to food security and nutrition. Let's delve into the distinctive features of three prominent millets: Pearl Millet, Sorghum, and Finger Millet.

1. **Pearl Millet *(Pennisetum glaucum)*:** Pearl Millet stands as a staple in various regions, notably India, Western and Central Africa, Eastern and Southern Africa. Its cultivation serves dual purposes: as a vital food grain in Asia and Africa and as

valuable fodder in the Americas. Beyond its versatility, Pearl Millet contain a high phosphorus content, promoting bone health. Additionally, it contains iron and folic acid, crucial for preventing anemia, particularly in pregnant women. Notably, compared to traditional cereals like rice and wheat, Pearl Millet stands out with its high fiber content, beneficial for sugar and weight control.

2. **Sorghum (*Sorghum bicolor*):** Widely recognized by names such as Great Millet, Jowar, and various others, Sorghum thrives in diverse regions, including the USA, Nigeria, Sudan, Mexico, and India. Its cultivation serves the dual purpose of food grain production in Asia and Africa and fodder in the Americas. Sorghum's nutritional profile is impressive, featuring high magnesium levels facilitating efficient calcium absorption. Rich in phenolic compounds and antioxidants, Sorghum is celebrated for its health benefits. Notably, its low glycemic index makes it a valuable component in diabetes prevention.
3. **Finger Millet (*Eleusine coracana*):** Known by various names such as Ragi, Bird's Foot, and Wimbi, Finger Millet finds cultivation in countries like India, Ethiopia, and Uganda. Its applications extend to food grain and beer making in Asia and Africa. What sets Finger Millet apart is its exceptional richness in calcium, surpassing even milk and other cereals. With three times more calcium than milk, it becomes a crucial dietary source. Moreover, its high protein and carbohydrate content make it an ideal choice for weaning food, especially for infants. Finger Millet's reputation for porridge making further underscores its nutritional significance.

Minor millets, often overshadowed by their major counterparts, play a pivotal role in global agriculture, contributing not only to food security but also offering unique health benefits. Here's a closer look at five significant minor millets: Foxtail Millet, Proso Millet, Little Millet, Kodo Millet, and Barnyard Millet.

- **Foxtail Millet (*Setaria italica*):** Known by various names such as Italian, German, and Hungarian, Foxtail Millet finds cultivation in China, Myanmar, India, and Eastern Europe. This versatile millet serves both as a food grain and a feed crop. Notably, Foxtail Millet thrives in rainfed areas due to its impressive drought tolerance, making it a resilient and essential crop in challenging agricultural environments.

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- **Proso Millet (*Panicum milliaceum*):** Widely recognized by names like common, hog, and broom millet, Proso Millet is cultivated across diverse regions, including Russia, USA, Ukraine, and India. Primarily used for food grain and bird seed, Proso Millet holds a special place in organic farming systems. Its adaptability and versatility contribute to its popularity in various agricultural practices.
- **Little Millet (*Panicum sumatrense*):** Known as Blue Panic and Heen Meneri, Little Millet is predominantly grown in India, serving the purpose of food grain production. The standout feature of Little Millet lies in its drought-tolerant nature, making it a vital crop in rainfed areas. Its resilience to water scarcity adds to its significance in agricultural landscapes.
- **Kodo Millet (*Paspalum scrobiculatum*):** Cultivated mainly in India and known by names like Varagu and Indian Paspalum, Kodo Millet is valued for its food grain production. Despite being a minor millet, Kodo Millet contributes significantly to local agricultural practices, providing a source of nourishment and livelihood for many communities.
- **Barnyard Millet (*Echinochola crusgalli*):** Referred to as Japanese, Sanwa, and Korean Millet, Barnyard Millet finds cultivation in countries such as India, Japan, China, and Malaysia. Primarily used for food grain purposes, Barnyard Millet stands out with its recommendation for patients with cardiovascular diseases. This nutritional consideration adds a health-focused dimension to its cultivation and consumption.

In conclusion, these millets, often cultivated in diverse geographical regions, bring resilience, adaptability, and unique nutritional benefits to the agricultural landscape. Rich in vitamins, minerals, protein, fiber, and antioxidants, these millets contribute not only to food security but also to potential health benefits, making them an integral part of the global effort towards sustainable and nutritious agriculture.

Promoting Millets: National and International levels

In 2018, the Indian government took a notable stride in revitalizing millets by designating it as the "National Year of Millets." Millets are acknowledged for their significant potential in addressing global challenges such as climate change and food security. Recognizing their significance, Prime Minister Narendra Modi suggested observing 2023 as the International Year of Millets, aiming to establish India as the "global hub of

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millets." This forward-thinking proposal garnered support from 72 other countries, and it was formally endorsed by the United Nations General Assembly during its 75th session in March 2022.

The International Year of Millets serves as a global platform to highlight the significance of these grains in addressing serious disputes like food security, climate change resilience and sustainable agriculture. This initiative resonates with the ancient Indian philosophy of "Vasudhaiva Kutumbakam," which emphasizes the idea that the world is one family.

Culinary Versatility of Millets

Millets exhibit remarkable culinary adaptability, as they can undergo various processing methods to yield diverse forms, including whole grains and flour, through the application of different processing technologies. Notably, millet grains can be finely ground to produce flour, a versatile ingredient employed in the preparation of an extensive array of dishes such as flatbreads, pancakes, and noodles. Furthermore, millet flour serves as a key component in the formulation of gluten-free bakery items, including bread, muffins, and cookies. Its functional attributes extend to acting as a proficient thickening agent in soups, stews, and gravies, contributing not only to flavor enhancement but also ensuring optimal consistency.

Millets are renowned for their culinary adaptability, finding common use in the preparation of porridge and fermented items such as idli and dosa, which stand as popular breakfast choices across various cultures. The versatility of millets extends to beverage production, encompassing millet-based beer and traditional drinks. For instance, finger millet takes center stage in the production of the South Indian beverage known as "ragi malt," while pearl millet contributes to the crafting of "bantu beer." Additionally, innovative processing techniques like extrusion can be employed to create popped millet, akin to the popular snack popcorn.

In summary, the culinary potential of millets is vast, owing to their adaptability and rich nutritional profile. Their application spans a broad spectrum, from traditional dishes to innovative food products, showcasing the diverse ways in which millets can be integrated into culinary practices.

Challenges to incorporate millets in diets

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Numerous regions are shifting from millet to staples like wheat and rice. This disconnect arises as contemporary diets favour mainstream options over millets.

A key barrier is the lack of awareness about millets' nutritional benefits. Labelling millets as the 'poor man's grain' inaccurately associates them with inferior quality, discouraging their inclusion in diets. Dispelling misconceptions and enhancing awareness is crucial for renewed appreciation. Marketing influences millet purchases, often portraying them as inferior. Limited processing technology hampers product diversification, affecting demand, especially in urban areas.Taste preferences for familiar cereals like rice and wheat hinder millet acceptance. This preference is a major barrier to promoting millet products.

Commercial factors, with rice and wheat included in the Public Distribution System at lower prices, make them more affordable than millets. Affordability considerations influence grain consumption. Limited availability in specific regions poses a challenge for those wanting to incorporate millets into their diets. Frustration arises when millets are unavailable in local markets, dissuading potential buyers.

A lack of culinary knowledge and millet recipe awareness hampers the ongoing shift towards millet consumption. Sufficient awareness and guidance are crucial for overcoming this hesitancy.

Solution

There are few solutions to overcome the challenges in millets marketing.

Awareness creation

Awareness campaigns about millets can be conducted using a variety of methods to encourage their addition in individuals' diets. Social media plays a key role as a game-changer through diverse posts, tweets, and videos. Collaborating with social media influencers can extend the reach to a larger audience. Media coverage in newspapers, magazines, radio, and television allows us to reach the masses.

Organizing food fairs and festivals provides an opportunity to engage people by offering millet tastings, thereby challenging and altering their perceptions regarding the taste of millets. Additionally, the development of various websites and apps can engage a wider audience, providing easy access to information and resources about millets.

Educate about nutritional and health benefits

There is a need to educate people that millets are not just a 'poor man's food' but rather a smart food choice for the 21st century. This can be achieved by including millets in

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school programs, distributing information about millets through pamphlets, posters, and various news articles. Additionally, adding nutritional labels on product packaging and sharing success stories online can raise awareness among individual consumers about the benefits of millets.

Marketing and branding

Marketing can be initiated by establishing a strong brand identity. This involves various processes such as packaging, sorting, and grading. Implementing diverse promotional strategies, including influencer marketing, poster campaigns and distributing templates, can be effective. Sampling and testing should be conducted, followed by asking customer reviews to measure millet product marketing success. Adjust your strategies based on customer insights to boost results.

Product diversification

Product diversification should align with demand and supply trends, allowing for adjustments based on customer preferences. Recipe development is crucial for product diversification, especially for making various products like ready-to-eat and ready-to-cook items made from millets. This development process involves enhancing flavour, texture and appearance to make the products more appealing to consumers.

Government initiatives

There is a need for government intervention in the millet sector. The government should provide subsidies to millet cultivators and support processors. Infrastructure development is essential for processing and adding value to millets. Additionally, including millet grains into the Public Distribution System (PDS) can increase the affordability of millet products.

Retail availability

Increase the availability of millet products in both rural and urban markets by making them readily accessible in retail shops that provide to the specific preferences and needs of consumers, thereby encouraging greater millet consumption.

Recipe promotion and workshops

Recipe promotion and workshops, which focus on developing and promoting millet-based dishes, can help engage consumers in incorporating millets into their diets. These initiatives not only introduce consumers to the culinary versatility of millets but also empower them with the knowledge and skills to prepare delicious and nutritious millet meals at home, ultimately contributing to a healthier and more sustainable diet.

Conclusion

Millets were once labelled as 'poor man’s food,' but in recent times, awareness has increased, and millets are emerging as the smart food of the 21st century. The reasons behind the popularity of millets are their nutritional benefits and their environmentally and farmer-friendly nature. Government support is needed in various forms, including subsidies, schemes, and other incentives, to incorporate millets into the diet of individuals. Furthermore, awareness campaigns and educational programs play a crucial role. Millets are not just grains; they are seeds of healthier and more environmentally conscious behaviour.

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Mitigating Soil Salinity Stress with Gypsum

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Introduction

Gypsum is essential in saline soil for its ability to improve soil structure and reduce soil salinity. It helps in enhancing water infiltration and drainage, which are often hindered in saline soils due to high salt concentrations. Gypsum also promotes root growth and nutrient uptake by plants, making it easier for them to access essential minerals in the soil. By counteracting the negative effects of excessive salts, gypsum plays a crucial role in reclaiming and improving the fertility of saline soil, enabling successful agricultural practices and plant growth.

How Gypsum Mitigate the Saline Soil?

Gypsum helps to reclaim saline soil through a process called flocculation. When gypsum is applied to saline soil, it reacts with the sodium ions present in the soil and replaces them with calcium ions. This exchange reduces the overall concentration of sodium in the soil and helps to break apart the soil particles, creating aggregates or clumps.

These aggregates have larger spaces between them, which improves the soil's structure and allows for better water infiltration and drainage. As a result, excess salts are leached out of the soil more efficiently, reducing soil salinity levels.

Additionally, the calcium supplied by gypsum enhances the availability of other nutrients in the soil, making them more accessible to plants. This improvement in soil structure and nutrient availability creates a more favorable environment for plant growth, helping to reclaim the saline soil and make it suitable for agricultural or other land use purposes.

How Saline Soil Is Hazardous for Plant Growth?

Saline soil is hazardous for plant growth due to its high concentration of salts, particularly sodium chloride (common table salt), which adversely affects the ability of plants to absorb water and essential nutrients from the soil. The excess salts create an unfavorable osmotic environment, leading to the following issues:

- **Reduced water uptake:** The high salt concentration in the soil creates a water potential gradient that draws water away from plant roots, making it challenging for plants to take up water effectively. This leads to water stress, dehydration, and wilting.
- **Ion toxicity:** Excess salts in the soil can cause an imbalance of essential ions, such as potassium, calcium, and magnesium, leading to ion toxicity. This disrupts various physiological processes in plants and affects their growth and overall health.
- **Nutrient deficiency**: The high salt content interferes with the availability and uptake of essential nutrients, such as nitrogen, phosphorus, and potassium, which are crucial for plant growth and development.
- **Stunted growth:** Saline soil inhibits root growth, reducing the plant's ability to anchor itself and acquire water and nutrients. This results in stunted growth and poor overall development.
- **Leaf burn:** The accumulation of salts on the leaf surface can lead to leaf burn or necrosis, further hampering the plant's photosynthetic capacity.

Advantages of Gypsum in Saline Soil?

Gypsum offers several advantages in saline soil, making it an effective amendment for reclamation and improving soil conditions:

- **Soil structure improvement:** Gypsum promotes flocculation, which creates aggregates or clumps in the soil. This improves soil structure by increasing pore spaces, allowing for better water infiltration and drainage. It prevents the soil from becoming compacted, which is common in saline soils.
- **Reduced soil salinity:** Gypsum helps reduce the concentration of sodium in saline soil by replacing sodium ions with calcium ions. This process, known as ion exchange, lowers soil salinity, making it less harmful to plant growth.
- **Enhanced water penetration:** Saline soils often suffer from poor water penetration due to high salt levels. Gypsum improves water infiltration by breaking down soil particles and creating channels for water to move through, reducing the risk of water logging.
- **Nutrient availability:** Gypsum supplies calcium, an essential nutrient for plant growth, and improves the availability of other nutrients in the soil. It helps counteract

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the negative effects of excessive salts on nutrient uptake, leading to improved plant nutrition.

- **Plant tolerance to salt stress:** Applying gypsum to saline soil can help improve plant tolerance to salt stress. By reducing the osmotic stress caused by high salt concentrations, plants can better manage water uptake and maintain better growth and health.
- **Environmental benefits:** Gypsum is a naturally occurring mineral and poses no environmental hazards. Its use in saline soil reclamation contributes to sustainable land management practices and reduces the potential for soil and water pollution.

Overall, gypsum is an important soil amendment in saline environments, as it addresses various challenges associated with high soil salinity, fostering better conditions for plant growth and enhancing the productivity of the land.

Disadvantages of Gypsum in Saline Soil

- **Insufficient remediation:** Gypsum can be effective in moderately saline soils but may not be the most effective solution for highly saline soils. In extreme cases of salinity, additional measures and more intensive reclamation techniques may be required.
- **Cost and application logistics:** Applying gypsum to large areas can be costly and labor-intensive. Transporting and distributing gypsum over expansive saline soil regions may present logistical challenges.
- **Delayed results:** While gypsum can initiate the process of soil reclamation, the results may not be instantaneous. It may take time for the gypsum to react with the soil and improve its structure and salinity levels, leading to a delayed impact on plant growth.
- **Limited long-term impact:** Gypsum's effects on soil improvement and salinity reduction may diminish over time. Continued monitoring and management practices might be necessary to sustain the improvements achieved through gypsum application.
- **Soil-specific effectiveness:** The efficacy of gypsum can vary depending on the specific soil characteristics and the types of salts present. Some soils may respond better to other reclamation strategies or a combination of different amendments.

- **Potential nutrient imbalances:** Applying gypsum in excessive amounts might alter the nutrient balance in the soil, particularly increasing calcium levels. Careful soil testing and balanced application are crucial to avoid potential nutrient imbalances.

Conclusion

Saline soil presents a challenging environment for plants, restricting their access to water and nutrients and negatively impacting their growth, health, and productivity. Reclamation with gypsum can help mitigate these hazards and restore the soil to a more suitable condition for plant growth and can contribute significantly to improving soil structure, reducing salinity. However, a comprehensive soil assessment and an understanding of the specific site's needs are essential to implementing an effective reclamation plan.

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Mycorrhizal Association with Litchi Production

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Mycorrhiza is a symbiotic mutualistic association between special soil fungi and fine plant roots. The fungus may invade host plant roots in a mycorrhizal relationship, either intercellularly or extracellularly. The fungi play an important role in plant health by improving nutrient and water uptake by their host plant and providing protection against soil-borne pathogens (Ryan and Graham, 2002). In return, the fungi receive carbohydrates and growth factors from the host plant.

Litchi is an important evergreen, subtropical fruit crop in India and is relished by people all across the world irrespective of its short period of availability in the market. In India, litchi is cultivated over an area of approximately 99,000 hectares, with a production of 7.37 lakh metric tons and a productivity of 7.43 tons/ha (Pathak *et al.*, 2023). Bihar followed by West Bengal and Uttar Pradesh are the main litchi producing states in the country. The heart to oval-shaped fruits is well known for their exquisite flavor, aroma, and nutritive values. The fruits are highly perishable and available for 45-50 days in the market in an entire year. The roots of litchi exhibit a mycorrhizal association with Arbuscular Mycorrhizal Fungi (AMF) which in turn aids in increasing the yield of the plant. This chapter focuses on understanding how the interaction of AMF with the litchi rhizosphere helps to enhance the potential productivity of the litchi.

Classification of Mycorrhizae

Albert Bernard Frank coined the term mycorrhiza in 1885 and it originated from the Greek words mycos, meaning ‘fungus’, and rhiza, meaning ‘roots’. Based on morphological and anatomical features mycorrhizae are classified into:

1. **Ectomycorrhizae**: The ectomycorrhizae consist of a hyphal sheath covering the root apex and a Hartig hyphal network that surrounds the plant cells in the root cortex. They form symbiotic relationships with approximately 10% of the plant families characteristic of conifers.

2. **Endomycorrhizae**: The mycorrhizae that grow intercellularly and form structures within the cortical cells of the roots are called endomycorrhizae. In the contact area between the fungus and the plant, the membranes of the fungus and the plant are in direct contact with each other. They form symbiotic relationships in almost 80 percent of plant families. There are several types of endomycorrhizae, the most well-known being Arbuscular Mycorrhizae (AM).
3. **Ectendomycorrhizae:** They share the characteristic features of both ectomycorrhizae and endomycorrhizae and have a poorly developed Hyphal coat. They are usually associated with *Eucalyptus* sp. and *Salix* sp. as host plants.

Table 1: Difference between ectomycorrhiza and endomycorrhiza

ECTOMYCORRHIZAE	ENDOMYCORRHIZAE
1. The fungal hyphae do not penetrate the cortical cells of the plant root	1. The fungal hyphae penetrate the cortical cells of the plant root
2. Produces a Hartig Net between the cells in the root cortex	2. Produces branched hyphae called arbuscules inside the cells in plant roots
3. Forms extracellular colonization	3. Forms intracellular colonization
4. Hyphal Mantle present	4. Hyphal Mantle absent
5. Less prevalent	5. More prevalent

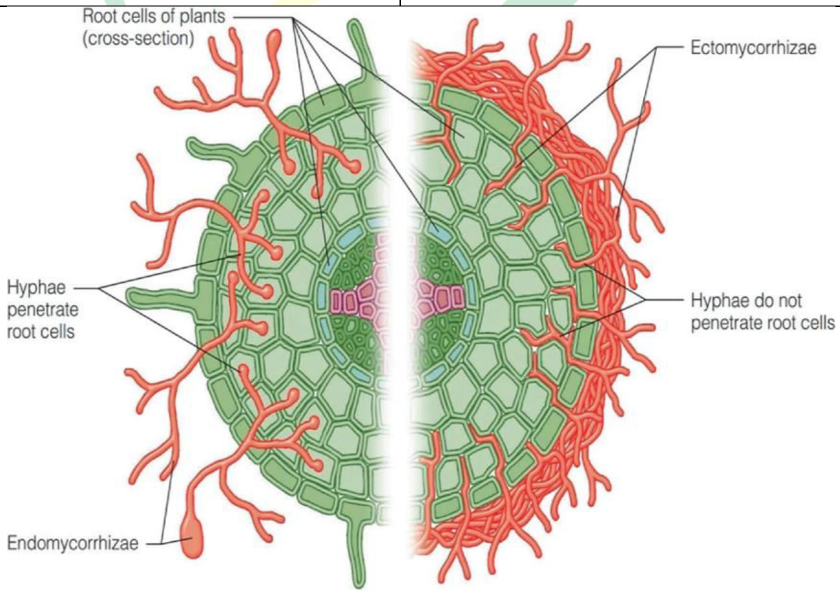

Figure 1: Hypae of Endomycorrizae and Ectomycorrhizae invading root cells

Arbuscular Mycorrhizae

They are endomycorrhizae whose hyphae invade plant cells and produce either balloon-like structures called vesicles or bifurcate invaginations called arbuscules to exchange nutrients such as phosphorus, carbon, and water. Fungal hyphae do not penetrate the protoplast but rather penetrate the cell membrane. The arbuscule structure significantly increases the contact area between hyphae and cytoplasm, facilitating nutrient transfer between hyphae and cytoplasm.

Presence of Mycorrhizae In Litchi Rhizosphere

Litchi (*Litchi chinensis* Sonn) is an important subtropical fruit crop native to the subtropics of China. It is known as queen of fruits due to its attractive deep pink to red colours and fragrant aril. Litchi usually prefers growing in slightly acidic to neutral well-drained soil with a pH ranging from 6 to 6.5. The roots of litchi trees are found to have a symbiotic association with mycorrhizal fungi which improves the nutrient uptake and availability in the root zone.

Role of Mycorrhizae in Litchi Production

Litchi is an important fruit crop and the nation demands quality and quantity production from its orchards. However modern agricultural practices avoid the use of chemical fertilizers and promote bio-fertilizers. This growing trend of biological fertilizers leads to the exploitation of the microbial association of mycorrhiza in Litchi's rhizosphere. This association is recognized as Vesicular Arbuscular Mycorrhizae (VAM). Mycorrhizal fungi are advantageous for plant growth because they facilitate the uptake of nutrients and minerals by plants as well as the conveyance of water. Coville was the first to report the presence of AMF in the cortical cells of litchi roots. AMF results in root infections that are characterized by strongly branching arbuscules that grow inside the host's cortical cells, as well as intercellular hyphae and vesicles (Dohroo *et al.*, 2013). The primary role of the vesicles is to store food for the fungus, and the nutrients are transported by the arbuscules. These Arbuscular mycorrhizal fungi (AMF) express a high affinity for phosphorous uptake which helps plants absorb large amounts of phosphorous with ease.

a) **AMF's Impact on the Soil's Phosphorus Content:** Plants absorb phosphorus in the form of orthophosphates, a mineral form of the element that is scarce in the soil. As a result of the soil's low mobility and delayed Phosphorous delivery, huge depletion zones rapidly form around roots. Therefore, the reservoir of phosphorus needs to be hydrolyzed before plants can absorb it from the soil. Arbuscular Mycorrhizal fungi plays a major role in improving the availability of Phosphorus in the soil. However, AMF cannot release phosphatases into the soil (Zhang *et al*., 2016) and hence they recruit Phosphate Solubilising Bacteria (PSB) that produce phosphatase, which mineralizes the organic P provides for a function that the AMF lacks (Zhang *et al*., 2018; Etesami and Jeong, 2021). PSB and AMF interact to mineralize insoluble phosphate in the soil and liberate soluble phosphate that is readily absorbed by plants (Wei *et al.,* 2017). According to this association, AMF mycelia enhance plant absorption of soluble phosphorus, while PSB is responsible for producing organic acids, including gluconic acid, keto gluconic acid, siderophores, protons, and acid phosphatases, which are involved in the mineralization of organic phosphorus in soil.

b) **Contribution of AMF on Soil Nitrogen Availability**: The AMF mycelium can absorb nitrogen in the form of ammonium ions, in the form of nitrates, and in the form of amino acids

c) **Contribution of AMF on Soil Trace Elements Transfer:** AMF plays a key role in making essential elements like Ferrous and Zinc available to the plants due to which mycorrhizal plants exhibit twice the amount of Zn, Fe, and Mn as compared to non-mycorrhizal plants (Krishna and Bagyaraj, 1984).

AMF association in litchi orchards are reported to increase drought and heat tolerances in the plants as well as increase resistance to several detrimental diseases. AMF assists the plants in tide over various abiotic and biotic stresses. Yao *et al.* (2005) reported that the AMF *Gigaspora margarita* and *Glomus intraradices* when injected into *Litchi chinensis* seedlings seemed to increase the quantities of isopentenyl adenosine and indole-3-acetic acid (IAA) in the shoots and roots.

The inoculation of the litchi plant with AMF resulted in the enhancement of the plant's growth (Yao *et al*., 2005) and also showed a significant impact on the root system morphology of the plant (Kaldorf and Muller, 2000). According to a study by Yao *et al.* (2005), litchi plants inoculated with two VAM species—*Gigaspora margarita* and *Glomus intraradices*—show a significant increase in lateral root length. Sharma *et al.* (2009) also reported that dual inoculation of litchi with *Glomus fasciculatum* and

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Azotobacter species resulted in enhanced root length. It was reported previously that inoculation of litchi plants with AMF enhanced growth and development after propagation by air layering.

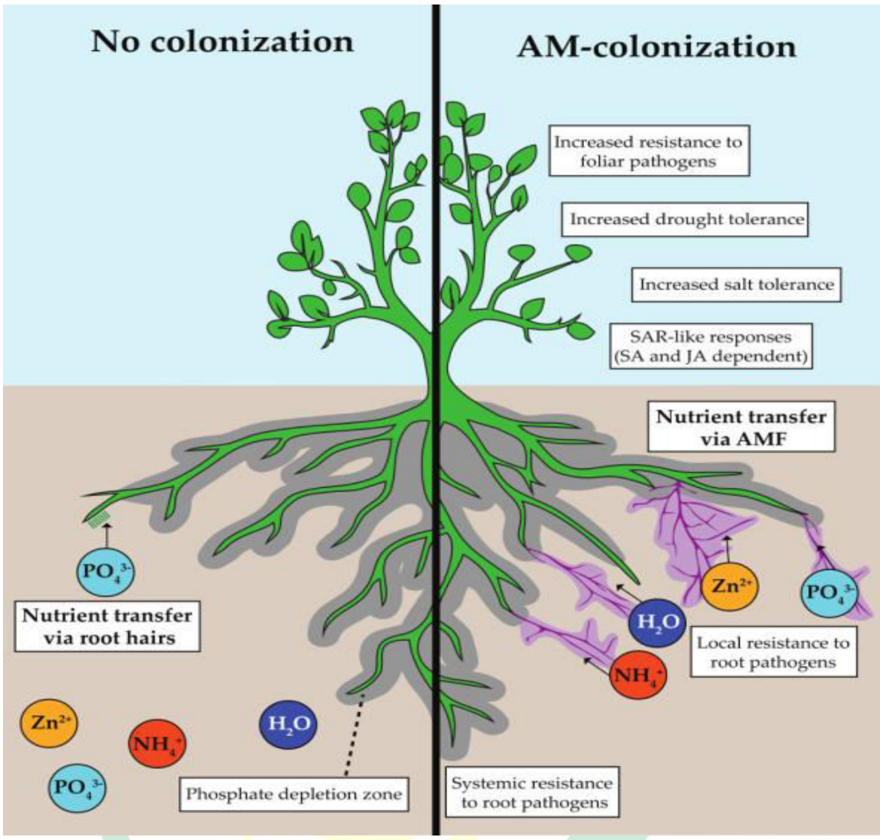

Figure 3: Benefits of AM fungi colonization

It has consistently been shown that the inoculation of litchi with mycorrhizal fungus promotes plant development. Since the beginning of time, litchi trees have been heavily dependent on AM fungus. The reason might be that the soil of older, more established litchi trees is used to inoculate the newly planted seedlings.

Conclusion

This article highlights the role of AMF in litchi plantations. Moreover, Arbuscular Mycorrhizal Fungi prove to be a suitable candidate for the production of sustainably produced. It also adds to the cost-effective cultivation of litchi as AM fungi reduce the application of chemical fertilizers to a great extent. In the Future, studies on the chemistry of exogenous and endogenous factors in AMF are required; in particular, how nutrients affect symbiotic signaling and the cellular programming that follows in the litchi rhizosphere.

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Nano DAP Fertilizer: Revolutionizing Agriculture with Advanced Technology

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ARTICLE ID: 31

Introduction: -

In recent years, the agricultural industry has witnessed a groundbreaking development in the form of Nano DAP (Di-Ammonia Phosphate) fertilizer. This innovative liquid fertilizer, manufactured by Indian Growers Fertiliser Cooperative Ltd (IFFCO), has been hailed as a game-changer for growers, with its potential to revolutionize crop growth and reduce production costs. In this comprehensive guide, we will explore the world of Nano DAP, its benefits, applications, dosage, and its role in making India self-reliant in the field of fertilizers.

The Concept of Nano DAP: Unleashing the Power of Nanoparticles: -

Nano DAP is a revolutionary fertilizer that harnesses the power of nanoparticles to enhance nutrient uptake and improve plant health. According to the ISO/BIS definition, nanoparticles are particles with at least one dimension in the size range of 1 nm to 100 nm. These tiny particles possess unique properties and exhibit improved performance compared to their bulk counterparts. In the case of Nano DAP, the nanoparticles of Di-Ammonia Phosphate are suspended in an aqueous solution, ready to be applied to crops.

Understanding the Benefits of Nano DAP for Crop Growth

Enhanced Nutrient Delivery and Efficiency: -

One of the key advantages of Nano DAP is its ability to deliver nutrients directly to plants in a highly efficient manner. Traditional fertilizers often suffer from low nutrient use efficiency (NUE) due to losses through leaching, fixation, and volatilization. Nano DAP, on the other hand, is taken up as a whole by plants, either through the roots or stomata. The small particle size and high surface area of Nano DAP enable efficient absorption, minimizing nutrient losses and maximizing nutrient availability for plant uptake.

Targeted Nutrient Release: -

Nano DAP addresses the critical requirement of phosphorus in chlorophyll for facilitating photosynthetic activity. The nano-sized particles of polymer-encapsulated DAP enter the plant through cuticular pores or stomata and penetrate cell membranes through endocytosis. Once inside the cell, the nano DAP particles slowly release phosphorus, ensuring a steady and adequate supply of this essential nutrient for photosynthesis.

Reduction in Environmental Impact: -

Another significant benefit of Nano DAP is its potential to reduce environmental pollution. Conventional fertilizers, when applied in excess or inefficiently, can contribute to soil, water, and air pollution. However, Nano DAP offers a more environmentally friendly approach to fertilization. Its efficient nutrient delivery system minimizes nutrient runoff, reducing the risk of water contamination. Additionally, the controlled release of nutrients ensures that they are utilized by plants effectively, minimizing wastage and potential harm to the environment.

Nano DAP: A Cost-Effective Solution for Growers

Cost Comparison with Traditional DAP: -

Nano DAP offers a cost-effective alternative to traditional DAP fertilizers. While a 50 kg bag of conventional DAP can cost growers around INR 1,350, a 500 ml bottle of Nano DAP is priced at just INR 600. This significant price difference makes Nano DAP a more affordable option for growers, allowing them to reduce their production costs without compromising on the quality of their crops.

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Traditional DAP	Nano DAP
50kg/acre	500ml/acre
₹1350/50kg	₹600/500ml

Application and Dosage Recommendations

- **Suitable Crops for Nano DAP: -** Nano DAP is a versatile fertilizer suitable for a wide range of crops, including cereals, fruits, vegetables, oilseeds, pulses, onions, cotton, and sugarcane. Its balanced ratio of nitrogen and phosphorus (8% Nitrogen and 16% Phosphorus) makes it an ideal choice for promoting crop establishment, flowering, and overall growth.
- **Recommended Dosage and Application: -** To maximize the benefits of Nano DAP, it is essential to follow the recommended dosage and application guidelines. For most crops, a dosage of 500 ml of Nano DAP per acre is recommended. It is advised to apply Nano DAP through foliar application, ensuring uniform coverage of the leaves. Two sprays are generally recommended - one at the vegetative stage (4-5 weeks after sowing/transplanting) and another before the flowering stage of the crop.

Conclusion

Nano DAP represents a significant leap forward in the field of fertilizers, harnessing the power of nanotechnology to optimize nutrient delivery and enhance crop growth. Its ability to improve nutrient use efficiency, reduce environmental impact, and lower production costs make it a game-changer for growers. With the support of the government, the agricultural sector is poised to embrace Nano DAP and reap its benefits, ultimately paving the way for a more self-reliant and sustainable agriculture industry in India. As Nano DAP continues to revolutionize crop production, it holds the promise of a brighter and more prosperous future for Indian growers and the nation as a whole.

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Nanoparticle: A Thrilling Antibacterial Key

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Introduction

Over the past few decades, there has been a significant increase in microbial infections in underdeveloped and developing countries, primarily due to the rapid growth of the human population. Diseases like Tuberculosis, Cholera, and Pneumonia have become widespread in tropical regions, and inadequate treatment can lead to fatal outcomes. In 1928, the discovery of penicillin marked the advent of antibiotics, which were subsequently developed and used to combat these microbial infections. However, the indiscriminate use of antibiotics has given rise to a concerning issue known as antibiotic resistance. This phenomenon occurs when certain antibiotics become ineffective against resistant bacteria. In some cases, infections become even more serious when pathogenic bacteria develop resistance to most available antibiotics, leading to a condition called Multi-Drug Resistance (MDR), which is associated with high mortality.

Common MDR problems include methicillin-resistant *Staphylococcus aureus* (MRSA), first identified in 1961. This strain not only resists methicillin but also several other commonly used drugs. *Staphylococcus*, a prevalent gut bacterium responsible for skin infections, can become life-threatening when it develops methicillin resistance. Another example is Extended Spectrum Beta-Lactamases (ESBL) enzymes, which enable bacteria like *Escherichia coli* and *Klebsiella pneumonia* to resist antibiotics. Nowadays, Multi-Drug Resistance has become a global issue and a leading cause of death. Addressing this problem urgently requires the development of alternative approaches to antibiotics. Notably, nanoparticles (NPs) have surfaced as a promising substitute for antibiotics, offering novel avenues to combat bacterial pathogens owing to their distinctive antimicrobial characteristics.

History behind nanotechnology

Nanotechnology, a groundbreaking field of research that emerged in the last century, has ushered in a new era of scientific exploration. The term "nanotechnology" was coined by

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Richard P. Feynman in his renowned 1959 lecture titled "There's Plenty of Room at the Bottom"[1]. The word "nano" is derived from the Greek term for "dwarf," signifying its focus on manipulating matter at the nanoscale, typically less than 100 nanometers in size. Nanotechnology involves working with microscopic particles of macromolecules at the nanoscale and has begun to significantly influence various aspects of human daily life. This technology enables the creation of different types of nanomaterials through three primary methods: physical methods, chemical methods, and green synthesis. These approaches encompass both top-down and bottom-up strategies, involving the transformation of bulk materials into nano-sized particles or the self-assembly of atoms to produce nanoscale particles[2].

Application of nanotechnology

Nanotechnology holds crucial importance due to its widespread applications in various fields. Presently, nanomaterials are making a significant impact in diverse sectors such as wastewater treatment, nanoremediation, food processing and packaging, improving fuel cell efficiency, household appliances, the petroleum industry, the textile industry, and the production of cosmetics, among others. NPs are also utilized in agriculture, where they serve as fertilizers that can substantially enhance crop production. Furthermore, nanotechnology is instrumental in seed technology, the development of nano pesticides, weed management, and soil enhancement in the field of agriculture[3].

Implication of nanotechnology in biology

In the field of biology, nanotechnology plays a crucial role in various biological applications, streamlining disease detection and diagnosis. Notably, gold NPs are employed for precise cancer cell therapy in cancer research, reducing mortality rates in cases of prostate and colon cancer. Nanoprobes are designed to bind with specific target proteins, facilitating diagnostic processes and aiding genetic sequencing and gene mapping. NPs are invaluable in gene therapy for addressing genetic disorders. Tissue Engineering leverages nanoscale biopolymers for tissue repair and cell regeneration through cell transplants, creating biological substitutes. NPs, often combined with lipids and polymers, serve as efficient drug delivery vehicles, enhancing drug delivery precision, including across the blood-brain barrier. Nanotechnology also contributes to food safety by detecting foodborne pathogens using gold NPs as biosensors. Additionally, it plays a role in food packaging, with bio-nanocomposite films incorporating bioconjugated nanomaterials and using carbon nanotubes and nanoscale titanium dioxide particles to block UV light in plastic packaging. Various nanomaterials, such as metal NPs, carbon nanotubes, polymeric NPs, nanosheets, and nanorods, have made substantial contributions across diverse applications[4].

Reason to use NPs against MDR bacteria

The indiscriminate use of antibiotics has led to the widespread development of multi-drug-resistant bacterial strains (MDR), which are challenging to treat. However, there is a glimmer of hope in the form of nanomaterials. Metal NPs, in particular, have emerged as up-and-coming antimicrobial agents due to their remarkable ability to penetrate the blood-brain barrier and enter cells. In the ongoing battle between microbes and our immune system, the problem of unspecific binding often renders many medicines ineffective. NPs offer a unique advantage as they can operate at the molecular level, interacting with MDR microbes with exceptional specificity. In recent years, researchers have made significant strides in utilizing various NPs like silver, gold, aluminum, copper, cerium, cadmium, magnesium, nickel, selenium, palladium, titanium, zinc, and super-paramagnetic iron against MDR bacterial strains, yielding surprisingly positive results[5].

Present scenario of AMR research with NPs

NPs effectively inhibit bacterial activity by damaging the bacterial cell wall, DNA, and proteins, and generating reactive oxygen species (ROS). Silver NPs are emerging as highly efficient nanomaterials against MDR bacteria, and other NPs like copper, silver, and iron also exhibit strong bactericidal effects. In a study, it was documented that gold NPs displayed robust antimicrobial activity against *E. coli*, *Salmonella typhi*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* due to oxidative stress triggered by increased intracellular ROS production[6]. Recently, silver NPs have demonstrated antimicrobial effects against MDR strain by disrupting the bacterial cell wall[7]. Graphene oxide-iron oxide NPs have shown maximum antibacterial activity against methicillin-resistant *Staphylococcus aureus* (MRSA), as reported by Pan et al. (2016)[8]. In 2016, Md Ashfaq et al. highlighted the antimicrobial properties of copper oxide NPs[9]. Sometimes, silver, gold, or other nanohybrid compounds are employed to enhance antimicrobial activity against MRSA and other MDR bacteria[10].

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Conclusion and prospect

The alarming rise of MDR bacteria poses a significant and urgent threat to human health. To address these serious health challenges, antimicrobial nanotherapy offers a promising solution, utilizing NPs as a novel tool. In addition to their extensive therapeutic applications, many NPs have shown remarkable antibacterial properties. NPs are not only recognized as effective drug delivery vehicles in various biological systems but also hold the potential to establish an alternative treatment approach for combating such pathogens. This avenue represents a hopeful prospect for the future of healthcare, where NPs can play a pivotal role in addressing the growing concerns surrounding MDR bacteria and their impact on human health.

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Non- Chemical Approaches in Integrated Pest Management

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Abstract

Pesticides, crop protection systems, crop yields, and cropping practices may all be improved by employing pesticides. Insect resistance and a decreasing supply of active chemicals both represent future challenges to crop productivity. As a result, agricultural systems that rely less on synthetic pesticides must be developed. The environmental impact of pest management strategies must be reduced. Changes in plant protection practices against the harm caused by insect pests are also impacted by increased concerns about the potential health repercussions of pesticides, a loss in arable land per person, and the emergence of new pest complexes, which is expected to be accelerated by climate change. Although pesticides remain an important weapon in the fight against insect pests, their unregulated use has resulted in a number of negative consequences, including contamination of the environment, toxic residues, pest comeback, resistance to pesticides, disruption of natural enemies, and so on. This might be accomplished by combining a non-chemical, safer delivery system that is also more environmentally friendly, allowing the pest to be dealt with while causing the least amount of interruption to its natural adversaries. This situation enhances the necessity for alternative pest management approaches such as physical controls, mechanical controls, botanical controls, and bio-rational controls.

Keywords: Botanical, Environment, Non-chemical, Resurgence.

Introduction:

Insecticides made from chemicals are mostly used to control insect pests in agriculture. Farmers frequently use chemical pesticides in big quantities on a regular basis to reduce crop loss due to pests. Despite the use of large amounts of insecticides, crop loss rises for a variety of reasons, including the emergence of pest resistance, pest revival, and pest replacement, in addition to having a detrimental impact on the environment and human health by leaving harmful residues. As a result, eco-friendly management techniques must be developed. The use of chemical pesticides in agriculture has been reduced in recent year's thanks in large part to the increased interest in biological management of pests and diseases that harm farmed plants. Microbial control of pests is mediated by natural enemies like predators and parasitoids and microbial control is achieved utilizing beneficial microbes such as insect pathogenic bacteria, fungi, viruses, protozoa and nematodes. However, the demand for contaminant-free, high-quality crops has led to a movement towards non-chemical pest management and sustainable crops cultivation. To restore the productivity and sustainability of soil as well as plants, efforts have been made to implement alternative, eco-friendly and cost-effective pest and disease management strategies. CABI and TTRI are conducting a scientific study to evaluate the environmental and economic feasibility of applying biological or non-pesticide methods for plant protection. There is need to reduce the negative impacts of pest control methods on the environment. Increased concerns about the potential effects of pesticides on health, the reduction in arable land per capita **(Novartis, 1997)** and the evolution of pest complexes likely to be accelerated by climate changes also contribute to change in plant protection practices.

Components of Non- Chemical Approaches:

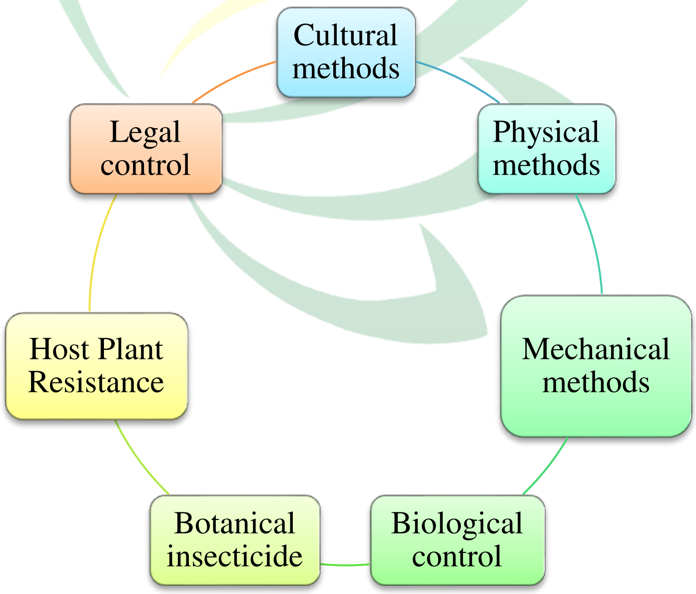

Fig:1 Components of Non- Chemical Approaches

a) **Cultural Control:** Cultural control refers to the control of insects through the adoption, at the appropriate time, of conventional form practices in such a way that the insects are either destroyed or decreased in a population.

Tillage:

During the summer, deep ploughing exposes the pupa in the fields to solar heat and natural enemies, reducing the population **(Reddy D.S., 2018).**

Sowing time

Early sowing reduced gall midge and leaf folders in rice, shoot fly in sorghum, *Helicoverpa armigera* in chick pea, and aphid in mustard.

Cotton bollworm damage can be reduced by planting on time.

Seed rate:

High seed rate use was proven to minimize termites in wheat and shoot flies in sorghum.

Plant spacing:

Closer spacing increases the likelihood of plant hoppers, whereas broader spacing increases the likelihood of leaf hoppers. The population of *Helicoverpa armigera* was four times higher in a closer-spaced chickpea crop.

Water management:

Crops grown in low-lying waterlogged environments suffer greatly from whitefly and termites.

Helicoverpa armigera reduced as the frequency of irrigations increased.

Management of nutrients:

Most insect pests are substantially more prevalent when nitrogen fertilizer levels are high. Many pests are reduced by the application of potash and, in certain cases, phosphorus.Excess nitrogenous fertilizer application reduced the damage caused by the shoot fly and stem borer, *Chilo partellus*.The use of nitrogen reduced the incidence of *Helicoverpa armigera* on tomato. White fly in sugarcane rose as nitrogen application was reduced.

Crop rotation entails:

If rice is produced after jute, for example, the jute stem weevil will be suppressed and will not attack rice.

Trap Crop:

- Mustard is used as a trap crop against the diamond back moth, *Plutella xylostella* (2:25 ratio) in cauliflower or cabbage fields. Mustard should be planted in matched rows (one 15 days after planting cabbage or cauliflower and another 30 days later).
- *Helicoverpa armigera* is attracted to trap cropping Marigold after every 8 rows tomato.
- Okra is a trap crop used to eliminate *Earias spp*. and *Amrasca devastans* in cotton.

Intercropping:

- A tomato intercropped with cabbage (1:1) reduced *Plutella xylostella* egg production.
- Cotton-cowpea intercropping attracted more coccinellid predators, resulting in increased natural parasitism of spotted bollworms.
- Cowpea is intercropped in groundnut farming systems to attract red hairy caterpillars.
- Proper harvesting reduces the frequency of rice stem borer in rice crops.

Physical techniques

These strategies try to control insect populations by using equipment that physically harm them or change their physical surroundings.

Treatment with hot or cold water:

Dry heat, including exposure to sun rays, is effective in eradicating a variety of pests in seeds and stored goods during the hot summer months of April to June. Grain bugs can be destroyed by heating them to 550 degrees Celsius for three hours. Cotton seeds exposed to sunlight in thin layers for 2-3 days in April help to kill diapausing larvae of the pink boll worm. The treatment of sugarcane setts using heat therapy units, either hot water or hot air, kills the scale insects that are brought over from the plant. Treatment of plant storage organs using hot water, such as roots, corns and bulbs.

Moisture content:

The moisture content of grain and that of the store house is a very important factor for controlling insects. Food grains with a moisture level below 11% are relatively resistant to insect attack, whereas moisture absorption. Content higher than 15% makes the grains susceptible to almost all types of insect pest attack. It is therefore recommended that grains be dried in the sun before storing so that its moisture content is not more than 8%.

a) **Mechanical Control:**

Mechanical devices or manual forces are used to manage pests in this sort of control.

Sticky trap:

Use yellow/blue sticky traps coated with castor oil to catch whiteflies, aphids, leaf miners, thrips, and other pests.

Luminous trap:

Before the introduction of synthetic organic insecticides, light traps for attracting and mass-killing months and beetles were utilized as a control strategy. The traps may still be effective for monitoring the population of major insect pests in a given area. The use of light traps to capture adults has proven effective in controlling Plessey borer, root borer, and whit grub damage in sugarcane. Monitoring unit of one light trap per acre, and mass collection unit of two to three per acre.

Table 1: Light trap to attract the different species

Common name	Scientific name	Different crop	Family	Order
American Bollworm	*Helicoverpa armigera*	Mungbean, Gram, Wheat, Vegetables, Cotton, Maize	Noctuidae	Lepidoptera
Armyworm	*Spodoptera litura*	Mung bean, Gram, Wheat, Vegetables, Cotton	Noctuidae	Lepidoptera
Termites	*Microtermes* Spp.	All crops, vegetables and ornamentals	Termitidae	Isoptera
Green Bug	*Chinavia hilaris*	Mungbean, Gram, Vegetables, Cotton	Pentatomidae	Hemiptera
Grey weevil	*Myllocerus virdidanus*	Mungbean, Cotton	Curculionoida	Coleoptera

b) **Biological control**

According to **Paul De Bach (1964)** "The utilization of parasites, parasitoids, predators and pathogens for the regulation of host population density is called as biological control."

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Component of Biological control:

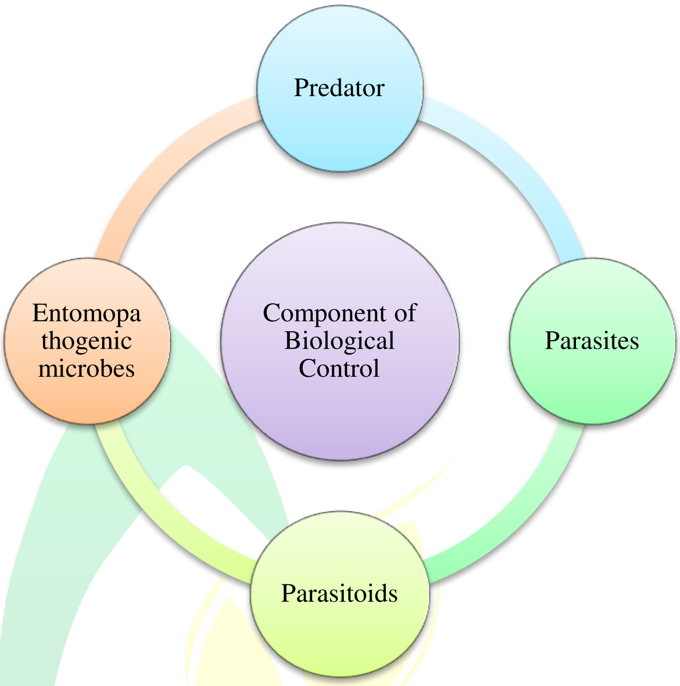

Fig-2: Components of biological control

d) Botanical insecticide:

Botanical insecticides are a viable alternative to synthetic pesticides due to their non-phytotoxicity, biodegradability, and fast decomposition **(Shivkumara *et al*., 2019).**

Botanical insecticides outperform synthetic pesticides in the following ways:

1. Have little mammalian toxicity and so pose few or no health risks or environmental damage.
2. There is no chance of building resistance while using natural forms.
3. Because they are target specific, they are less dangerous to non-target creatures such as parasites, predators, and pollinators.
4. It is not known what causes pest species recurrence.
5. It is not phytotoxic to crop plants.
6. They do not leave residues on crop produce or the environment, contributing to conservation and consumer safety.

e) Host Plant Resistance:

Insect host plant resistance (HPR) is a low-cost, ecologically friendly pest management strategy. The most enticing feature of HPR is that farmers do not need much experience with application techniques or to invest any money. Significant progress has been made in the discovery and creation of agricultural cultivars resistance to major pests in a variety of crops. Resistance genes must be bred into high-yielding cultivars capable of adapting to a wide range of agro ecosystems. Insect resistance should be one of the criterion for releasing varieties and hybrids to farmer cultivation. HPR can be turned into an effective weapon for decreasing insect pest losses by combining genes from wild relatives of crops with unique genes from *Bacillus thuringiensis*.

f) Legal control:

Restriction on the transportation of certain commodities within or beyond the country, or between various parts of the country, by enacting specific laws and regulations. Citrus greening, for example, is a big problem in Pokhara, and movement of seedlings and grafts from Pokhara to various parts is legal regulation**.**

Why is non-chemical insect pest treatment preferred?

To overcome the problems of following we preferred non- chemical approaches for pest management

- Insect resistance to pesticides is developing.
- The resurgence of the treated population.
- Secondary pest outbreak.
- Food and forage residue.
- Pollution of the environment and deterioration of its quality.
- Extermination of non-target animals and natural enemies.
- Dangers to human health

Conclusion:

The uncontrolled use of pesticides that are chemical-based has resulted in insecticide resistance, contamination of the environment, pest resurrection, secondary pest outbreaks, and a reduction in the number of natural enemies. In recent years, IPM-based pest control practices have become more useful and applicable for pest management. In this technique, pest populations are kept below ETL by the use of cultural, biological, physical, mechanical, and legal approaches to insect pest management. Non-chemical insect pest control is a feasible answer to this issue. In the long run, this method poses no risk to human health, the environment, or natural adversaries.

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Novel Genic Markers for Genetic Improvement of Pomegranate

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Abstract

The generation of marker resources and development of genetic maps with breeding applications is crucial for the genetic improvement of pomegranates. Next-generation sequencing (NGS) technologies have helped to generate huge genomic resources in pomegranate that incudes genome, transcriptome of coding and noncoding RNAs sequencing. These findings have provided direct access to a huge number of gene models and their families of pomegranate. Based on gene information we could develop novel gene-based markers resources like micro-RNA based simple sequence repeats (miRNA-SSRs), potential intron polymorphism (PIP) and insertion deletions (InDels) markers for applied research in pomegranate. Since, gene-based markers would show functional differences at the trait level directly. Breeders can thus bypass linkage drag by choosing the segregating progenies of various crossings during breeding directly at the gene level. Therefore, we assume that these markers would be an invaluable resource for future trait mapping and gene discovery applications to enable gene editing in pomegranates. There by significantly hasten pomegranate genetic improvement and lead to the development of elite cultivars with significant export potential.

Keywords: Pomegranate, Gene, Markers, Genome, Breeding

Introduction

The discovery of new genes and SNP markers, identification of gene families, study of evolution, creation of transcriptome maps, identification of metabolic pathways, and other applications were the immense promise of next-generation sequencing (NGS) technologies in plant genome research (Blanca et al., 2012). The generation of marker resources and development of genetic maps with breeding applications is crucial for the genetic improvement of pomegranate. Consequently, the creation of gene-based DNA marker systems in pomegranate may substantially aid in genomics assisted genetic advancement in the future (Patil et al., 2020a, c).

Through international efforts on pomegranate genome sequencing, at present four genomes are publically accessible on NCBI, the largest of which is "Bhagawa" at 342 Mb, followed by "Dabenzi" at 328 Mb, "Tunisia" at 320 Mb, and "Taishanhong" at 274 Mb. In order to create useful gene-based markers resources like single nucleotide polymorphisms (SNPs), insertion deletions (InDels), and simple sequence repeat markers, these findings have provided direct access to a huge number of gene models and their families. Furthermore, the development of gene based functional DNA markers in pomegranates, such as EST-SSRs, EST-SNPs (Ono et al., 2011; Ophir et al., 2014), and miRNA-SSRs (Patil et al., 2020b), has been made possible by the availability of transcriptome sequencing of coding and noncoding RNAs. The high throughput genetic analysis needed for pomegranate genetic improvement may be aided by these marker resources. However, lesser polymorphism potential and the requirement for specialized, expensive platforms for marker genotyping are the drawbacks that prevent the widespread use of these gene-based DNA markers.

Harel-Beja et al. (2015) previously shown usefulness of SNP markers for identifying 25 QTLs for pomegranate fruit quality attributes. Trainin et al., (2021) also conducted a fine mapping of the candidate gene, anthocyanidin reductase (*ANR*) with a point mutation that causes the black peel colour in pomegranates. This allowed for the development of an SNP-based functional marker for fruit colour. Deploying gene-based DNA markers is therefore more crucial to improving pomegranate breeding efficiency. This call for the urgent development of effective gene-based marker systems that are widely distributed throughout the genome and that can show polymorphism on basic genotyping platforms (Badoni et al., 2016). Because gene-based markers have remained relatively stable over evolutionary time across genera, they serve as the foundation for comparative genome research in pomegranates.

Micro-RNA based markers

In many organisms, including plants, short RNAs (sRNAs) are recognized as the primary genetic and epigenetic regulators. These have the ability to alter DNA, modify histone methylations, and change the amount of coding (mRNA) or non-coding RNAs, which in turn controls how traits are regulated. MicroRNAs (miRNAs) and small interfering RNAs (siRNAs) are the two main regulatory sRNAs identified in plants. MiRNAs predominantly engage in post transcriptional regulation, while siRNAs largely involve transcriptional control (Chen et al., 2018).

The NCBI database now has more genomic information due to the sequencing of the pomegranate genome and its coding and non-coding RNAs (http://www.ncbi.nlm.nih.gov). Due to the fact that polymorphisms in MIR genes encoding miRNAs are known to change the expression, specificity, and/or targeting ability of miRNAs, this can ultimately change the expression of many phenotypic traits. This sequence information has aided in the characterization of the MIR genes that encode miRNAs and has contributed to the development of the first set of large-scale genome-wide miRNA-SSRs. In total, 1054 miRNA-SSRs specific to seedling to fruit developmental stages (Patil et al., 2020b) and 132 miRNA-SSRs specific to seed hardness traits (Patil et al., 2022a) have been designed. In rice, for example, salt sensitive (trait specific) miRNA-SSRs have been discovered by previous researchers (Mondal and Ganie, 2013; Ganie and Mondal, 2015), who have linked them to gene expression and salt tolerant phenotype. The pomegranate miRNA-SSRs may therefore be useful for discovering master miRNAs that control different genes for fruit quality attributes. Eventually, these miRNAs may be used in genome editing programmes to develop pomegranates varieties with desired fruits (Patil et al., 2020b).

Intron Length Markers (ILM)

Introns are the gene sequence components and are abundant in the majority of eukaryotic genomes. Because there was less purifying selection pressure during evolution, these introns have remained less varied and less conserved than coding areas. According to Badoni et al. (2016), introns can serve as highly polymorphic genetic markers. These markers have been shown to exhibit more plant intra-species variability than other types of markers, while being based on genic regions (Muthamilarasan et al., 2014). Due to its unique properties, including as direct depiction of variation within certain genes and subspecies, intron length polymorphism (ILP) is becoming more and more popular. Its advantages over SSR markers are especially noteworthy (Wang et al., 2006). As that of SSR markers cross-species amplification became possible for ILP primers that are designed to conserved flanking exons to amplify introns. Therefore based on intron position predictions across species, Yang et al. (2007) created a database of potential intron polymorphism (PIP) markers. Using this data base, PIP markers have been developed in many plant species and not yet in pomegranate. Given their enormous advantages in terms of subspecies specificity, neutrality (no phenotypic effect), and the capacity to perform test variation within genes, PIP markers could be employed in conjunction with SSR markers to establish genetic diversity (Huang et al., 2013).

The whole genome sequencing of numerous crops has provided an increasing amount of information on structurally and functionally annotated genes, which is a valuable resource for the creation of ILP markers across the entire genome. In comparison to other DNA marker systems, there are still very few studies on the development of ILP markers in fruit trees. Genome-wide markers (SSR, ILP, and PIP) were previously reported by Xia et al. (2017) using data from 16 sequenced tree species. Despite the availability of whole genome sequences for four pomegranate genotypes, no research on ILP markers has been published yet. In light of this, we have recently designed 8,812 potential intron polymorphism (PIP) markers that are unique to 3,445 (13.40%) gene models that are distributed across 8 Tunisian chromosomes. Also, we demonstrated their potential utility for genetic analysis by studying genetic diversity among 31 pomegranate genotypes (Patil et al., 2022b). These markers would be an invaluable resource for research on genetic variation, finding functional genes, and genomics-assisted pomegranate breeding.

Insertion/Deletion (InDeL) Markers

The genetic structural alterations that are extensively distributed across the genomes of plants are known to be mostly caused by insertion-deletions, or InDels. Many of the desired intrinsic genetic features of SSR and SNP markers are present in InDels, including co-dominance, abundance, and random distribution throughout the genome (Lv et al., 2016; Pan et al., 2021). InDel markers have emerged as substitutes for SSR and SNP markers (Garcia-Lor et al. 2013). Recently, there has been increased interest in PCR-based InDels due to their potential to identify polymorphism (Vasemagi et al. 2010). Especially when it comes to trait mapping and genotyping, it is crucial to remember that InDels offer more potential than SSRs. A number studies have effectively finished the in-depth examination of important gene families implicated in development and growth in pomegranate *viz*., sucrose synthase (SUS), sucrose transporter (SUT), and exported transporter (SWEET), as well as gene families for transcription factors like three-amino-acid-loop-extension (TALEs), YABBY, auxin responsive factors (ARFs), and basic leucine zipper (bZIP). *In silico* examination of these gene families through multiple sequence alignment across four pomegranate genomes led to the designing of 245 unique InDel markers that targeted 140 genes involved in growth and development. Further, the immediate utility of these markers for genetic analysis was proved through genetic diversity study in 16 pomegranate genotypes (Un published). InDel marker developed here may prove to be very useful for future trait mapping and gene discovery applications to enable gene editing in pomegranates.

Conclusion

The deployment of gene-based markers would significantly hasten pomegranate genetic improvement and lead to the development of elite cultivars with significant export potential. Gene-based markers would show functional differences at the trait level directly. Breeders can thus bypass linkage drag by choosing the segregating progenies of various crossings during breeding directly at the gene level. The development of gene-based marker resources in pomegranates may definitely help to identify their allelic variability for prospective genome editing applications to breed superior varieties with improved traits.

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Nutritional Factors and Health Benefits of Green Leaf Vegetables

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Introduction

Green leafy vegetables hold a significant position among food crops since they offer sufficient levels of many vitamins and minerals for people. They are a good source of minerals including calcium, iron, and phosphorus as well as vitamins like beta-carotene, ascorbic acid, riboflavin, and folic acid. There are numerous underutilized greens in nature with promising nutritional content that can feed the world's expanding population. Green leafy vegetables are essential for human nourishment, particularly in developing nations. India is blessed with a range of natural landscapes, variable climatic conditions, and changing seasons, which result in a variety of leafy vegetable species (Kumar *et al*., 2020). Vegetables are frequently referred to as "protective foods" in human diets due to the variety of health benefits they provide due to their high vitamin, essential fatty acid, mineral, amino acid, and dietary fiber content (Shukla *et al*., 2016). Green leafy vegetables are a blessing for a safe and healthier life and have been in use for centuries. They provide adequate amounts of many vitamins and minerals for humans (Randhawa, 2015)

Nutritional factors of green leafy vegetables:

- **Vitamins-** Vitamins are abundant in green leafy veggies. Antioxidant vitamin C plays a critical role in the immune system's defense against bacteria, viruses, and other pathogens. Vegetables that are lush green, spinach is packed with of nutrients. Boiled spinach has 573 micrograms (mcg) of vitamin A per half-cup, or 229% of the dietary value (DV). Spinach may help decrease blood pressure and strengthen the heart, according to some research. Compared to mature plants, fresh, young leaves have more vitamin C content. Compared to the white interior leaves, the green outer leaves of lettuce and cabbage are higher in vitamins. Greater and thinner leaves are often lower in calories and higher in nutrients. Plant meals contain carotenoids, such as betacarotene, which the body must transform into vitamin A (Trumbo *et al.,* 2001).

- **Proteins-** Made up of different combinations of amino acids, proteins are large, complicated molecules. In all living things, proteins are essential for maintaining cellular structure, functions, and metabolic activity control. As a result, proteins take precedence in consumers' everyday meals. The most affordable and highest-quality sources of protein are green leafy vegetables. This results from their capacity to produce and accumulate amino acids with the aid of a plentiful supply of light, water, oxygen, and nitrogen, all of which are easily found in the environment (Aletor *et al.,* 2002).
- **Dietary fiber**- It has long been known that green leafy vegetables are an excellent source of dietary fiber. Epidemiological research indicates that dietary fiber, particularly that found in leafy vegetables like celery, cabbage, spinach, and lettuce, which are known for having a high water content and a high percentage of fiber, is essential in preventing a number of disorders. Additionally, it has been discovered that fiber lowers cholesterol by lessening the body's re absorption of cholesterol that is created to aid in fat digestion. The cabbage family of vegetables, which includes turnips, broccoli, cauliflower, and cabbage, has chemicals that may be useful in preventing cancer (Otles *et al.,* 2014).
- **Minerals-** The inorganic compounds known as minerals are necessary for your body to operate correctly. Our bodies contain millions of microscopic cells that need vital nutrients to proliferate. Numerous sources provide these minerals, which include calcium, iron, zinc, and selenium. These minerals have the potential to support hormone secretion, muscle contraction, hormonal balance, bone formation, carbohydrate metabolism, and fluid balance. Our body's mineral imbalance is the root cause of a large number of ailments. Minerals must be obtained from food and water since neither humans nor animals are able to create them (Mohammed and Sharif, 2011).
- **Essential fatty acids**- Since our bodies are unable to synthesize omega-3, it is necessary for us to consume it orally. Omega-3 is a vital nutrient. Given that it provides several health benefits, this chemical is quite advantageous. It lowers the

risk of heart disease, enhances memory, enhances brain function, controls blood pressure, and manages diabetes, among other health advantages (Da Silva and Imai, 2017). Normal growth and development are dependent on omega-3 fatty acids, which are also essential for the prevention and treatment of autoimmune and inflammatory disorders like as cancer, diabetes, hypertension, coronary artery disease, and arthritis (Hamazaki and Okuyama, 2001).

Health benefits of green leafy vegetables

- Green leafy vegetables are essential for healthy growth of body**,** as they contain all vital essential nutrients.
- Vegetables have been firmly linked to improved gastrointestinal and visual health, decreased risk of heart disease, stroke, diabetes, anemia, gastric ulcers, rheumatoid arthritis, and other chronic illnesses, as well as general well-being.
- The phytochemicals present in fresh vegetables possess anti-inflammatory, enzyme-inhibiting, and bioactive properties that can effectively counteract the effects of oxidants. It was once thought that the key to human nutrition and health was a combination of 16 vital minerals and 14 vitamins.
- Iron and mineral nutrients are particularly abundant in leafy plants. Anaemia, a prevalent health issue in youngsters as well as pregnant and breastfeeding women, is caused by iron deficiency.
- One of the many health advantages of fermenting cabbage is that it can be made into sauerkraut, which boosts immunity and aids in digestion. It might even help you lose weight.
- A great supply of folate is found in leafy green vegetables. Folate is thought to be involved in the synthesis of hormones or neurotransmitters that regulate mood, such as serotonin and dopamine**.**

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Organic Earthen Pot Arkh – Reviving the Ancient Wisdom

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Abstract:

ITK is the unique knowledge that examines traditional knowledge which includes modern technology with current experiences. ITK are the source for improving knowledge and developing technology. It helps in reducing reliance on foreign inputs and encourages eco-friendly agriculture which benefits farmers in remote areas. Organic earthen pot arkh is one of the ITK's which is the easiest method and requires easily affordable ingredients. The organic earthen pot has having greater influence on farmers to manage the farming system and is very beneficial to rural farmers. Organic earthen pot arkh reflects the ancient methods of natural farming.

Introduction

There are many ITK practices all over India. The vast knowledge provided by these ITKs assists natural farming. Most of these practises are practiced by using natural materials available in their localities. Based on current technology the skills may be outdated. There are many ITK to stretch the skills and knowledge about organic farming to the rural farmers as this ITK includes Neem leaves – which acts as an antiseptic and is harmful to flour beetles, and bean-shaped beetle. It increases the availability of nitrogen fertilizer and reduces the rate of nitrification. It prevents storage pests. Pongamia leaves –show an anti-feedant or repellent effect on many insects which avoids treating crops. It acts as similar Insecticidal properties of neem and also acts as green manure. Calotropis leaves- act as a soil binder.it is an indicator of overgrazed, it consists of the nematicidal property. Jaggery – it acts as a natural growth promoter for the crops. It acts as a good source of energy and helps the plant to grow healthier and stronger. It is a good source of micro and macronutrients. It helps in the stimulation of plant growth. It also helps maintain the natural balance in the ecosystem. Cow

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urine- enhances the nutrient uptake by plants and is also a natural fertilizer for crops. It consists of nitrogen, Phosphorus and Potassium which are the major nutrients required for plant growth. Acts as liquid fertilizer as a pesticide for plants.

Materials and method of preparation

Organic earthen pot Arkh is very economical as it is a cost-effective and easiest process and also requires less period. For the preparation of 1 litre of organic earthen pot arkh required 1 unit of earthen pot, 1 litre of cow urine, 250 grams of fresh neem leaves, 250 grams of calotropis leaves, 250 grams of Pongamia leaves, 10 grams of jaggery. After the collection of fresh leaves. The leaves are to be crushed before adding them to the pot. 1 litre of cow urine is added into the pot along with the 10 grams of jaggery. The earthen pot is recommended as it is non-reactive with the formulation. Followed by the addition of crushed (250 gm Neem, 250gm.calotropis, 250gm. Pongamia) leaves. Then the solution is to be stirred till the jaggery melts down and the ingredients get mixed well.

Fig1.1 Pongamia leaves

Fig1.2 Calotropis leaves

Fig1.3 neem leaves

Fig1.4 jaggery

Fig1.5 cow urine

Fig1.6 day1 to day6

Fig1.7 day6 to day10

Fig1.8 Final extract

The earthen pot is to be tied up by covering it with a clean cloth to avoid microbial contamination and left for fermentation for about 7 to 10 days. During these 10 days per every 2 days of interval, the solution is to be mixed up with a stick. The addition of water in between the process is avoided which disturbs the fermentation process. After 10 days the liquid fertilizer is extracted from the earthen pot with the addition of 1 litre of cow urine.

Things to Know About Organic Earthen Pot

Application of organic earthen pot arkh can be done to the soil by diluting 20 ml of extract per 1 litre of water and can be sprayed or drenched the soil with the help of rose cane for control of pests and diseases and the direct application is prevented. For bulk quantity a minimum of 5lit.of cow urine,5kg. of Neem leaves, 5kg. of Calotropis leaves 5kg. of Pongamia leaves and 50gm. of jaggery is used. The earthen pot arkh must be placed in a shaded place to prevent sunlight.The total production cost is 10₹ for 10 grams of jaggery and 100₹ for earthen pot. The advantages of organic earthen pot arkh are:

- Organic earthen pot (ITK) which is considered an effective organic liquid fertilizer that enhances the productivity of crops.
- Soil fertility: enhances the availability of nutrients in the soil.
- Investment: it is not an expensive process as all the ingredients are available naturally in the surrounding environment.
- It is renewable, eco-friendly and biodegradable.

Conclusion:

Organic earthen pot arkh is one of the traditional ITK which includes more traditional knowledge which has been followed from ancient days and is considered as most effective against various pest and diseases as the neem leaves and cow urine contains antimicrobial agents which helps in preventing disease transmission in plants. The use of natural products in preparation can improve health and nutritional values in soil, crops and humans.

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Pigeonpea Crop Wild Relatives and Pre-Breeding: Unlocking Genetic Resources for Sustainable Agriculture

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Introduction

Pigeonpea (*Cajanus cajan*) is an important legume crop widely cultivated in semi-arid regions of the world. It serves as a critical source of protein, income, and soil fertility improvement for millions of smallholder farmers. However, like many crops, pigeonpea faces numerous challenges, including biotic and abiotic stresses. To address these challenges, pigeonpea pre-breeding programs have turned to the utilization of crop wild relatives (CWRs) as a valuable genetic resource. This explores the significance of pigeonpea CWRs and the pre-breeding strategies aimed at improving this crop for enhanced sustainability and resilience in agriculture.

Pigeonpea and Its Importance

Pigeonpea is native to the Indian subcontinent, and its domestication history dates back over 3,500 years. It is recognized for its ability to fix atmospheric nitrogen and improve soil fertility, making it an integral part of traditional cropping systems. The crop is nutritionally rich, providing a valuable source of dietary protein, especially in regions where meat consumption is limited. Pigeonpea has been traditionally consumed in various forms, from dhal (split pigeonpea) to a variety of curries and snacks.

Despite its importance, pigeonpea faces several constraints that limit its productivity. Drought, diseases, and insect pests are among the primary challenges that pigeonpea farmer's encounter. The long growth duration of pigeonpea cultivars often makes them susceptible to these challenges, leading to yield losses and diminished farmer livelihoods. To address these limitations, the use of pigeonpea CWRs has become vital in pigeonpea improvement programs.

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The Significance of Pigeonpea Crop Wild Relatives

Crop wild relatives are species closely related to cultivated crops, sharing a common gene pool. They are essential genetic resources for crop improvement, as they often possess unique traits that can be transferred to cultivated crops through breeding. Pigeonpea has several wild relatives within the *Cajanus* genus, such as *Cajanus scarabaeoides* and *Cajanus platycarpus*. These wild relatives have evolved in diverse environments and carry traits that can be valuable for enhancing pigeonpea resilience and adaptability. Some of the notable traits include resistance to diseases and pests, tolerance to abiotic stresses like drought and salinity, and early maturity.

Pre-breeding Importance

While wild Cajanus species offer abundant resistance potential, their underutilization in pigeonpea breeding programs remains a significant issue. This limitation primarily stems from linkage drag and incompatibility barriers between cultivated and wild species. In such circumstances, pre-breeding represents a distinct opportunity to enhance the primary gene pool by tapping into the genetic diversity present in both wild species and cultivated germplasm. This approach ensures a consistent influx of fresh and valuable genetic variation into breeding pipelines, facilitating the development of new cultivars characterized by robust resistance and a wide genetic foundation.

Pre-breeding Strategies in Pigeonpea Improvement

Pre-breeding is a critical phase in crop improvement where genetic diversity from CWRs is incorporated into cultivated varieties. This process aims to develop breeding lines with improved traits that can subsequently be used in commercial breeding programs. In pigeonpea pre-breeding, several strategies have been employed to harness the potential of CWRs:

1. **Trait Introgression:** The primary objective of pre-breeding is the identification of desirable traits and/or genes from unadapted germplasm such as exotic landraces/wild species (donors) and introgress them into cultivated pigeonpea varieties. The introgression of traits like disease resistance and drought tolerance from CWRs has shown promise in developing improved pigeonpea lines. Advanced genomic tools, such as molecular markers, have facilitated the tracking of target traits during introgression.

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2. **Population Development:** Pigeonpea pre-breeding programs often focus on developing populations following hybridization for transferring these traits into well-adapted genetic backgrounds. Several pre-breeding populations have been developed at ICRISAT utilizing wild species from *C. cajanifolius*, *C. acutifolius*, *C. scarabaeoides* and *C. platycarpus* having useful traits such as tolerance to salinity and pod borer resistance in crop improvement programs.
3. **Genetic Mapping and Marker-Assisted Breeding:** The availability of genomic resources and molecular markers has revolutionized pre-breeding efforts in pigeonpea. By identifying and mapping genes associated with target traits, such as resistance to Fusarium wilt or pod borer resistance, breeders can efficiently select and cross lines to develop improved cultivars.
4. **High Throughput Phenotyping:** Accurate phenotyping is crucial in pre-breeding to evaluate the performance of introgressed traits under different conditions. High-throughput phenotyping techniques, including remote sensing, can help breeders identify promising lines with stress tolerance, ensuring the success of pigeonpea improvement programs.
5. **Conservation and Preservation:** Pigeonpea CWRs are invaluable genetic resources, and their preservation is essential. Conservation efforts are essential to safeguard the genetic diversity found in these wild relatives, ensuring that they remain available for pigeonpea improvement in the future.

Conclusion

Pigeonpea is a crucial crop in the context of global food security and sustainable agriculture. As the world faces increasing challenges from climate change, pigeonpea pre-breeding programs are turning to crop wild relatives to enhance the resilience and productivity of this crop. Pigeonpea CWRs carry valuable traits that can address the challenges faced by farmers, including drought, diseases, and pests. Through pre-breeding strategies such as trait introgression, heterosis and hybrid development, genetic mapping, and advanced phenotyping, pigeonpea improvement programs are well-positioned to harness the potential of these wild relatives and develop more robust and sustainable pigeonpea varieties for the future. By doing so, they can contribute to global food security and the well-being of smallholder farmers worldwide.

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Role of Feed Additives in Poultry

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Introduction:

Feed additives are minor components of the animal ration and are used for improving the quality/digestibility of feed and the nutritive and aesthetic quality of food or improving animal performance and health. Some of the most commonly used feed additives in animal rations includes pro- and prebiotics, antioxidants, antibiotic growth promoters, and coloring agents. Overall, these different ingredients are aimed at enhancing digestibility or availability of bound nutrients (e.g., enzymes), improving animal gut health (e.g., pro/prebiotics) and food product quality (e.g., antioxidants), reducing nutrient loss (e.g., phosphorus, nitrogen), and promoting environmental protection.

An additive is a substance that is added to a basic feed, usually in small quantities, for the purpose of fortifying it with certain nutrients, stimulants or medicines other than as a direct source of nutrient. In general, the term “feed additive” refers to a non-nutritive product that affects utilisation of the feed or productive performance of the animal.

Additives That Enhance Feed Intake

Antioxidants

- Antioxidants are compounds that prevent oxidative rancidity of polyunsaturated fats. Rancidity once develops, may cause destruction of fat-soluble vitamins A, D and E and many B complex vitamins.
- Breakdown products of rancidity may react with lysine and thus affects the protein value of the ration. Eg. Ethoxyquin or BHT, (butylated hydroxytoluene) act as antioxidant in feed.

Flavouring Agent

- Flavouring agents are feed additives that are supposed to increase palatability and feed intake. There is need for flavouring agents when highly unpalatable medicants are being mixed, during attacks of diseases, when animals are under stress, and when a less palatable feedstuffs is being fed either as such or being incorporated in the ration.

Additives That Enhance the Colour

- Additives that enhance the colour or quality of the marketed product
- Poultry man will often enhance the yellow colour by adding xanthophylls into broiler feed.
- Among various additives, arsanilic acid, sodium arsanilate and roxarsone are also added for the purpose.

Grit

- Poultry do not have teeth to grind any hard grain, most grinding takes place in the thick musculated gizzard.
- The more thoroughly feed is ground, the more surface area is created for digestion and subsequent absorption. Hence, when hard, coarse or fibrous feeds are fed to poultry, grit is sometimes added to supply additional surface for grinding within gizzard.
- The value of grit become less, when mash or finely ground feeds are fed. Oyster shells, coquina shells and limestone are used as grit.

Buffers and Neutralisers

- During maximum production stage ruminants are given high doses of concentrate feeds for meeting demands for extra energy and protein requirement of the animal.

- The condition on the other hand lowers the pH of the rumen. Since many of the rumen microbes cannot tolerate low pH environment, the normally heterogeneous balanced population of microbes become skewed, favouring the acidophilic (acid-loving) bacteria.
- The condition often leads to acidosis and thereby upsets normal digestion.
- The addition of feed buffers and neutralisers, such as carbonates, bicarbonates, hydroxides, oxides, salts of VFA, phosphate salts, ammonium chloride and sodium sulphate have been shown to have beneficial effects.

Chelates

- Organic chelates of mineral elements, which are cyclic compounds, are the most important factors controlling absorption of a number ofmineral elements.

  Chelates may be of naturally occurring substances such as chlorophyll, cytochromes, haemoglobin, vitamin B12, some amino acids, etc.,or may be of synthetic substances like ethylene diamine tetracetic acid (EDTA.)

Additives That Promote Growth and Production

Antibiotics

- These are substances which are produced by living organisms (mould, bacteria or green plants) and which in small concentration have bacteriostatic or bactericidal properties.
- They were originally developed for medical and veterinary purposes to control specific pathogenic organisms.
- Later it was discovered that certain antibiotics could increase the rate of growth of young pigs and chicks when included in their diet in small amounts.
- Soon after this report a wide range of antibiotics have been tested and the following have been shown to have growth promoting properties: penicillin, oxytetracycline (Terramycin), chlortetracycline, bacitracin, streptomycin, tyrothricin, gramicidin, neomycin, erythromycin and flavomycin.
- Increased weight gain is most evident during the period of rapid growth and then decreases.
- Differences between control and treated animals are greater when the diet is

slightly deficient or marginal in protein, B-vitamins or certain mineral elements.

Probiotics

- It is defined as a live microbial feed supplement, which beneficially affects the host animals by improving its intestional microbial balance. The probiotic preparation is generally composed of organisms of lactobacilli and/or streptococci species, few many contain yeast caltones.
- They benefit the host by:
  1. Having a direct antagonistic effect against specific group of undesirable or harmful organism through production of antibacterial compounds, elementary or minimising their competition of nutrients.
  2. Altering the pattern of microbial metabolism in the gastro intentional tract.
  3. Boosting of immunity.
  4. Neutralisation of enterotoxins formed by pathegenic organism.
- Thus, resulting in improved feed efficiency and increased growth rate,

Additives That Affect the Health Status of Livestock

- **Antibloat compounds:** Surfactants such as poloxalene is used as a preventive for pasture bloat, several other products have been shown to be highly effective to prevent bloat are also available in the market.
- **Antifungal additives:**
  - **(i)** Mould inhibitors are added to feed liable to be contaminated with various types of fungi such as Aspergillus flavus, Penicillium cyclopium etc.
  - **(ii)** Before adding commercial inhibitors, all feedstuff should be dried below 10 percent moisture. Propionic, acetic acid and sodium propionate are added in high moisture grain to inhibit mould growth.
  - **(iii)** Antifungals such as Nystatin and copper sulphate preparations are also in use to concentrate feeds to prevent moulds.
- **Anticoccidials:** Various brands of anticocidials are now available in the country to prevent the growth of coccidia which are protozoa and live inside the cells of the intestinal lining of livestock.
- **Antihelmintics:** Under some practical feeding conditions anthelmintics have also been used. The compounds act by reducing parasitic infections.

- **Anticaking agents:** Anticaking agents are anhydrous substance that can pick up moisture without themselves becoming wet. They are added to dry mixes to prevent the particles clumping together and so keep the product free flowing.

They are either anhydrous salts or substance that hold water by surface adhesion yet themselves remain free flowing: Salt or longchain fatty acids.

A. Calcium phosphate

B. Potassium and sodium ferryocyanide

C. Magnesium oxide

D. Salts silicic acid – Al, Mg, Ca, Salt.

- Sodium aluminium silicate
- Sodium calcium aluminium silicate
- Calcium aluminium silicate

Conclusion

Each of these feed additives has their specific benefits.So Further research is needed to not only identify new hope for poultry feeds additives but also need to recognize that how combinations of these additives can be used to improve the efficiency of poultry production. Systematic approach is required to explain the efficacy and mode of action for each of type and dose of additives. Approvement of various feed additives for use is important. After that they should be utilized as directed with inclusion levels and duration of feeding. They should also be specific for the age of birds being fed. Non antibiotic growth promoters such as organic acids and probiotics should be used. Safety should be in mind to reduce the feed industry’s impact on the environment.