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Agroforestry: Paving the Way for a Climate-Resilient Future

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Introduction

As the world grapples with the escalating impacts of climate change, innovative solutions that integrate nature and human activity are gaining traction. One such solution is agroforestry, a sustainable land-use practice that integrates trees, crops, and livestock in a mutually beneficial system. Agroforestry not only enhances agricultural productivity but also plays a significant role in mitigating and adapting to climate change.

What is Agroforestry?

Agroforestry is the practice of intentionally integrating trees and shrubs into agricultural landscapes. Unlike monoculture farming, which relies on a single crop species, agroforestry promotes biodiversity and ecosystem services by growing a mix of plants, trees, and animals. These systems can vary from simple combinations of crops and trees to more complex designs that include forest-like environments with multiple species interacting.

The diversity of agroforestry systems offers several environmental, social, and economic benefits, which make it a powerful tool in the fight against climate change.

The Role of Agroforestry in Climate Change Mitigation

1. **Carbon Sequestration**

Agroforestry practices contribute to climate change mitigation primarily through carbon sequestration. Trees absorb carbon dioxide (CO2) from the atmosphere and store it in their biomass and soil. This makes agroforestry systems highly effective in reducing greenhouse gas concentrations. Studies show that agroforestry can sequester between 2 to 10 gigatons of carbon globally each year, depending on the type of system and location.

- **Soil Carbon Storage**: In addition to storing carbon in trees, agroforestry practices can increase soil organic matter, which also acts as a carbon sink. The roots of trees and other plants help improve soil structure, increasing its ability to retain carbon over long periods. This can significantly enhance soil fertility and health, benefiting both the environment and agricultural productivity.

2. **Biodiversity Preservation**

Agroforestry systems foster biodiversity by creating habitats for a wide variety of species. This not only improves ecosystem resilience but also supports pollinators, beneficial insects, and wildlife. By maintaining diverse landscapes, agroforestry systems help safeguard ecosystems that are crucial for maintaining the balance of the planet's climate.

Biodiversity also plays a vital role in building ecosystem resilience to climate impacts. For instance, diverse agroforestry systems are more resistant to pests, diseases, and extreme weather events, which are becoming more frequent due to climate change.

3. **Climate Resilience and Adaptation**

Agroforestry helps farmers adapt to changing climatic conditions. Trees and shrubs provide shade and windbreaks, reducing the impacts of temperature extremes, soil erosion, and water loss. By improving soil health and water retention, agroforestry can enhance the resilience of agricultural systems to droughts and floods.

- **Water Management**: Agroforestry systems can improve water infiltration and reduce runoff, helping to maintain water quality and availability, especially in areas prone to drought. Trees also help reduce the evaporation of water from the soil, which is particularly important in arid and semi-arid regions.

4. **Reduction in Land Degradation**

Deforestation and unsustainable farming practices contribute significantly to land degradation and loss of productive land. Agroforestry systems can help restore degraded lands, promote reforestation, and combat desertification. By integrating trees into agricultural practices, farmers can reduce soil erosion, improve water retention, and replenish vital soil nutrients.

For example, in Africa, agroforestry systems like the "fertilizer tree" method have been used to restore soils and improve food security in areas where land degradation was a major challenge. This method involves planting nitrogen-fixing trees alongside crops to enrich the soil and increase crop yields.

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Economic Benefits of Agroforestry

1. **Diversified Income Streams**

   Agroforestry can offer farmers new income streams by producing a variety of products such as fruits, nuts, timber, medicinal plants, and honey. These additional products can buffer farmers against the volatility of global commodity markets, providing a more stable income and financial security.

2. **Increased Crop Yields**

   Trees in agroforestry systems can enhance soil fertility and water retention, leading to improved crop yields over time. By reducing the need for chemical fertilizers and pesticides, agroforestry also lowers production costs, making farming more sustainable and economically viable in the long run.

3. **Rural Employment Opportunities**

   Agroforestry has the potential to create employment opportunities in rural areas, both directly (e.g., in tree planting, harvesting, and forest management) and indirectly (e.g., through the marketing and processing of agroforestry products). In many developing countries, this can significantly improve livelihoods and reduce rural poverty.

Fig: Different Agroforestry Systems

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Challenges to Implementing Agroforestry

Despite its potential, agroforestry faces several barriers to widespread adoption:

1. **Knowledge and Training Gaps**

   Many farmers, especially in developing countries, lack knowledge and technical expertise on agroforestry practices. Education and extension services are crucial to help farmers adopt these practices and understand their long-term benefits.

2. **Land Tenure and Policy Issues**

   In many regions, insecure land tenure can discourage farmers from investing in long-term agroforestry systems. Clear and supportive policies that recognize the benefits of agroforestry, including land tenure security, access to credit, and market incentives, are essential for scaling up these practices.

3. **Initial Investment Costs**

   The establishment of agroforestry systems can require significant initial investments, particularly for purchasing seedlings, tools, and training. Farmers may need financial support through subsidies, loans, or grants to adopt these systems, especially in low-income regions.

Conclusion

Agroforestry presents a promising pathway to mitigate climate change, protect biodiversity, and support sustainable agricultural practices. By integrating trees into agricultural systems, we can reduce greenhouse gas emissions, sequester carbon, enhance soil health, and promote resilience to climate impacts. However, widespread adoption of agroforestry requires strong policy support, financial investment, and education to overcome existing challenges.

Ultimately, agroforestry offers a unique opportunity to harmonize agricultural productivity with environmental conservation, creating a more sustainable and climate-resilient future for both farmers and the planet.

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Artificial Intelligence (AI) Significance in The Field of Animal Reproduction

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Introduction

AI has changed ICT industries by introducing new technologies like machine learning, deep learning, natural language processing, and robotic artificial neural networks. In other nations, farmers are highly skilled and key players in the economy. They seek advice from veterinarians; collect extensive live data for research which are processed by machine learning algorithms, resulting in valuable output that farmers utilize. AI-driven systems for observing animal behavior, identifying initial indications of illness, and environmental stressors impacting animal well-being through large number of data collection, data transfer, data storage, data analysis, and delivery of results have helped with various aspects of dairy farm management such as animal health, milk production, and reproduction. In addition to automating tasks, AI has also helped in reducing production costs and improving productivity. It has lessened animal stress through less human and animal interaction, and offered data-driven insights for improved decision-making. Additionally, this technology may possess greater accuracy than humans due to its ability to rapidly and efficiently analyze large quantities of data. This enables the recognition of patterns that are difficult to identify and decreases the subjectivity in analysis. The most common technologies farmers use to gather information about their animals is wearable sensors and computer vision techniques which depend on type of production system and number of animals. In case of sheep, goats, pigs, poultry, and fish, measurements are based on the entire group for the cost effectiveness.

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Sensors

A device that measures or detects various biological, physiological and biochemical processes, alone or in combination by continuous monitoring of individual animal. The information gathered is processed by a machine through data collection, later analyzed with Machine Learning and Deep Learning algorithms to predict deviations or abnormalities for precise decision-making purposes. Sensors can be categorized into two main groups: attached and non-attached. The first one involves using devices on or in the body of the animal. On the other hand, unattached sensors are placed away from the individual, and data collected when the animal passes or stays near their location. In-line and on-line sensors fall under this second category. Sensor data is gathered continuously by in-line sensors that are usually positioned within the production system, such as monitoring the electrical conductivity of milk by robotic milking machines. Alternatively, on-line sensors analyze Somatic Cell Count by automated sampling using internet.

Accelerometer provides information about an animal's behavior, health, nutrition, and reproductive status. Radio Frequency Identification (RFID) is utilized in various ways within livestock production systems for the purpose of identifying, tracking, and managing animals. This technology ensures accurate data collection from individual animals and quick transfer to a central database, minimizing errors. Force and pressure platforms enable the evaluation of the force and pressure exerted by an animal on the platforms. It examines the walking patterns of animals, providing information on the forces applied during both dynamic and static positions. Environmental sensors are utilized to gauge temperature, humidity, and other factors which play a crucial role in monitoring greenhouse gas emissions, and managing animal well-being, disease control, and production. Important technology i.e. wireless intra-ruminal sensors, like the SmaXtec system which gather information on rumen motility, pH, and body temperature. This technology has the potential to provide knowledge for the early detection of metabolic diseases like ruminal acidosis.

Computer Vision

- These technologies, particularly image and video analysis, have gained traction for their ability to extract detailed data in a non-invasive manner.
- Their real-time application enables precise animal-level monitoring.

Key Challenges:

- ✓ The efficiency of these systems depends significantly on camera quality.
- ✓ The number of animals in the frame can limit the simultaneous analysis capability, particularly in crowded environments.

Infrared Thermal Cameras:

- These cameras provide a means to monitor temperature variations across an animal's body by detecting infrared heat radiation.
- This is particularly useful for identifying stress, fever, or localized infections.

3D Cameras:

- ❖ These cameras are instrumental in reconstructing an animal's anatomy to analyze structural or anatomical defects.
- ❖ They indirectly assess critical health and productivity parameters like weight and body condition score (BCS), which are indicators of an animal's nutritional and health status.
- ❖ This facilitates early detection of negative energy balance or other health concerns, aiding in timely interventions.

AI Applications in Animal Reproduction

It has garnered significant attention in recent years, as researchers and scientists explore the potential of this technology to enhance and optimize various aspects of reproductive processes in a wide range of animal species. Artificial intelligence has been leveraged to tackle various challenges in animal reproduction, from improving breeding strategies to enhancing the accuracy of diagnostic tools and predictive models. Estrus detection has been a major issue in large herds, AI or Machine Learning algorithms has simplified it with the automated estrus detection tools, such as activity monitoring (pedometers, activity meters, and 3D accelerometers), milk progesterone level measurement (Biosensors and Immunostrips), mounting behavior observation (sensor and video camera), vocalization recording (microphone), and body temperature measurement (temperature transducer and bolus placed in cow's reticulum), pressure-triggered mount detectors, temperature gauge, and radio telemetric transmission. Computer vision using Deep Learning techniques was used for estrus detection to visualize stand to be mounted animals which are in heat with 95% accuracy rate.

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Artificial insemination is another domain where AI has found significant application. The use of AI techniques in the selection of high-quality spermatozoa and embryos has been the focus of extensive research, with the aim of improving the success rate of assisted reproductive technologies like ETT and OPU-IVF. Machine learning model was developed to accurately measure bull sperm motility in semen samples by using three CASA parameters (curvilinear velocity, straight line velocity, and linearity). Machine and deep learning algorithms are used to develop an AI tool that analyzes boar sperm to identify boars with low conception rates, so that boar with high genetic index can be used more efficiently in the herd. Many research studies used computer vision and machine learning/deep learning methods to evaluate embryo morphology and viability score, and transcriptomic data in combination to detect genes related to embryonic competency and viability for revealing possible causes of early pregnancy loss. These methods were capable of choosing viable embryos for implantation or cryopreservation, yielding better results than alternative methods. Furthermore, AI-driven models have been developed to optimize the timing and dosage of hormonal treatments, which can enhance the effectiveness of estrus synchronization and improve the overall reproductive performance of livestock.

While the integration of artificial intelligence in animal reproduction is still a relatively nascent field, the research conducted thus far has shown promising results. As the technology continues to evolve and become more widely adopted, the impact of AI on animal reproduction is expected to grow, leading to more efficient and sustainable animal farming practices, as well as the preservation of genetic diversity in threatened species

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Bakanae Disease in Rice: Cause, Symptoms, and Effective Management

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Introduction

Rice (*Oryza sativa* L.), a vital cereal of the Gramineae family, serves as the primary staple for nearly 65% of India's population. Under Punjab conditions, it is grown as major *Kharif* crop over an area of about 31.5 lakh ha with production of approximately 205.24 lakh tons. Rice production is challenged by various biotic factors, including insect pests, weeds, and diseases. Among these, diseases alone have been reported to cause 15-30% yield losses globally. Among diseases, foot rot of rice also known as "Bakanae disease" or "foolish seedling disease" is economically important disease of rice causing quantitative and qualitative loses to the crop.

Foot rot of rice is caused by different *Fusarium* species belonging to *Gibberella fujikuroi* species complex, with predominance of *F. fujikuroi* throughout the rice growing areas of the world. This disease was first reported in Japan in 1828, later it was reported from all rice growing areas of Asia, Africa and America. In India, the disease was reported by Thomas in 1931. The disease is prevalent in all rice growing states with higher incidence on Basmati rice varieties grown in Punjab and Haryana. This disease is responsible to cause upto 3.0 to 95.4% yield losses to the crop depending upon variety and geographical region. In India, 15-25% yield losses have been reported to be caused by this disease. Presently, under Punjab conditions, this disease is becoming the bottleneck for Basmati rice production, due to favorable environmental conditions for the pathogen.

Symptomatology

The symptoms of disease first appear on young rice seedlings in the nursery and continues after they are transplanted to the field. Common symptoms include seedling blight, root rot, crown rot, stunted growth, excessive elongation, foot rot, seedling rot, grain sterility, and grain discoloration. These symptoms have been reported in many rice-growing regions worldwide. Bakanae-infected seedlings grow taller than healthy ones, with yellowish-green stems and leaves that become lighter in

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color as the disease worsens. Some seedlings may survive in the nursery but often die soon after being transplanted. In India, the disease was called "foot rot" because infected plants developed adventitious roots from the lower part of the stem. A pinkish-white cottony fungal growth can also be seen at the base of infected plants.

Survival and Spread of pathogen

Bakanae is a monocyclic disease which is primarily seed borne in nature as it can survive in seed for over 4-10 months. However, soil and plant debris transmission have also been reported to some extent as soil borne inoculum rapidly reduces with time. The infection starts upon sowing of seed in the nursery. Ascospores and conidia adhering to the seed germinate and infect seedlings via roots and crown. Under favorable conditions, infected plants are capable of producing lots of conidia that subsequently infect neighboring plants. The conidia are easily transmitted via water and wind, and initiate new infections. Conidia formation on damaged or dead culms in the field corresponds to the crop's flowering stage which serves as inoculum for next year.

Predisposing factors

Various weather parameters, including temperature, relative humidity, and rainfall, significantly influence disease progression. Studies have shown that the optimal temperature for pathogen infection ranges from 27 to 30°C, while disease development is most favourable at 35°C, particularly under conditions of high relative humidity. Additionally, the incidence of Bakanae is reported to be higher in transplanted rice compared to directly seeded crops. Furthermore, aromatic rice varieties, such as Basmati, exhibit greater susceptibility to the disease than non-aromatic varieties.

Management of the disease

Physical Methods: Pre-sowing seed treatment by soaking seeds in hot water at 60ºC for 10 minutes has been shown to effectively reduce seed-borne infections and lower the incidence of Bakanae disease in both nursery and field conditions.

Resistant Varieties: The deployment of resistant cultivars remains the most cost-effective and environmentally sustainable approach for managing Bakanae disease in rice. Several rice genotypes, including PAU 3456-46-6-1-1, HKR 96-561, HKR 96-565, HKR 07-40, and MAUB2009-1, have exhibited resistance against Bakanae under controlled conditions using the seedling root dip inoculation method. However, no commercially available rice variety has yet been developed with confirmed resistance to this disease.

Cultural Control: Utilizing disease-free, non-infected seeds is a fundamental strategy for managing Bakanae in rice, as the pathogen is primarily seed-borne. The removal of lightweight, infected seeds through saltwater flotation can effectively reduce the initial inoculum. Integrating organic matter, crop rotation, optimized planting time and methods, selection of resistant cultivars, balanced fertilization, and proper irrigation management significantly contributes to disease suppression. Minimal disease incidence of Bakanae was observed in rice sown at the end of July. Additionally, nitrogen and potassium levels in soil influence pathogen survival and population dynamics, while the incorporation of neem cake has been shown to suppress the disease.

Biological Control: Employing biological control agents presents an eco-friendly alternative to chemical fungicides for disease management. Among fungal biocontrol agents, *Trichoderma viride, T. asperellum, T. atroviride,* and *T. neokoningii* have demonstrated significant efficacy in reducing Bakanae disease under field conditions. Likewise, bacterial antagonists such as *Pseudomonas fluorescens, Bacillus subtilis,* and *B. thuringiensis* have been reported to lower disease incidence in both nursery and field settings. A combined application of farmyard manure (10 tons/ha) along with *T. viride* and *P. fluorescens* has been found to effectively reduce Bakanae incidence in rice fields.

Chemical Control: The application of systemic fungicides remains one of the most effective and widely adopted strategies for managing Bakanae disease. Pre-sowing seed treatment with carbendazim or Thiram has proven to be highly efficient in controlling the pathogen. Additionally, treating rice seeds with Sprint fungicide (Mancozeb 25% + Carbendazim 50%) at a dosage of 3 g/kg seed before sowing has been reported as a highly effective approach for disease suppression.

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"Biofortification for Healthier Harvests: A Scientific Response to Iron and Zinc Deficiency"

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ABSTRACT

Micronutrient malnutrition, often referred to as "hidden hunger," affects over two billion people globally, with zinc and iron deficiencies being among the most prevalent and debilitating. These deficiencies compromise immune function, cognitive development, and overall health, especially in vulnerable populations such as children and pregnant women. Biofortification, the process of enhancing the nutritional content of food crops through biological means, has emerged as a sustainable and cost-effective approach to combat micronutrient deficiencies. Several approaches are employed in biofortification, including conventional plant breeding, agronomic practices (such as micronutrient fertilization), and modern biotechnological tools like genetic engineering and genome editing. Among these, breeding zinc- and iron-rich varieties of rice, wheat, maize, and beans has shown significant promise, supported by initiatives like Harvest Plus. Agronomic biofortification using zinc- and iron-enriched fertilizers also offers immediate but short-term solutions, particularly in soils deficient in these elements.

Introduction

Malnutrition is a broad term to indicate the conditions that may arise from both undernutrition and overnutrition. Undernutrition is associated with stunting (low height for age), wasting (low weight for height), being underweight (low weight for age) and micronutrient deficiencies, whereas overnutrition is associated with obesity, diet-related noncommunicable diseases (e.g., heart disease, stroke, diabetes and cancer) and being overweight.

Undernutrition is defined as the provision of an insufficient quantity of food elements (i.e., hidden hunger). Hunger is usually understood to refer to the suffering associated with lack of food, but can also refers to conditions when a sufficient quantity of food is provided with low levels of minerals and vitamins.

Micronutrients play an important role in the proper growth and development of the human body and its deficiency affects the health contributing to low productivity and vicious cycle of malnutrition, underdevelopment as well as poverty. Micronutrient deficiency is a public health problem affecting more than one-fourth of the global population. Several programmes have been launched over the years in India to improve nutrition and health status of the population; however, a large portion of the population is still affected by micronutrient deficiency. Anaemia, the most common form of micronutrient deficiency affects almost 50 to 60 per cent preschool children and women, while vitamin A deficiency and iodine-deficiency disorders (IDD) have improved over the years.

Nutritional insecurity is a major threat to the world's population that is highly dependent on cereals-based diet, deficient in micronutrients. Cereals and millets are nutritionally superior as their grains contain high amount of protein, essential amino acids, minerals, and vitamins. Biofortification of staple crops is proved to be an economically feasible approach to combat micronutrient malnutrition. Some groups and NGOs in India realized the importance of crop biofortification and released conventionally bred high iron and zinc rich crops in India to tackle iron deficiency.

Role of zinc in plant system

- **Zinc is constituent of enzyme -** Zinc plays an important role in the structure and function of many enzymes, including alcohol dehydrogenases (ADHs) of the MDR type (mediumchain dehydrogenases/reductases). Active site zinc participates in catalytic events, and structural site zinc maintains structural stability.
- **Protein metabolism -** Co-factor of a large no. of enzymes involved in "protein synthesis & also involved in stability and functioning of genetic material.
- **Carbohydrate metabolism**
- **Photosynthesis-** Constituent of Carbonic anhydrase (CA) enzyme, which have role in CO_2 fixation. CA contains a single Zn atom which catalysis the hydration of CO_2.

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- **Sucrose and Starch Formation**- Component of aldolase which involved in sucrose formation coupled with important role in starch metabolism.
- **Detoxification of super oxide radicals -** Zn involved in the 2 enzyme Cu-Zn-SOD (most abundant SOD in plant).
- **Anaerobic root respiration -** Carbonic anhydrase is involved in root respiration & Zn is a part of it.
- **Membrane integrity -** Structural orientation of macromolecules and maintenance of ion transport systems.
- **Auxin metabolism -** Required for synthesis of Auxin, while reduction in Zn reduces the level of auxins in plants.
- **Uptake and Stress -** Water uptake and transport in plants and alleviate short prairies of heat and salt stress.
- **Synthesis of cytochrome C -** Cytochrome c is primarily known for its function in the mitochondria as a key participant in the life-supporting function of ATP synthesis.

Role of iron in plant system

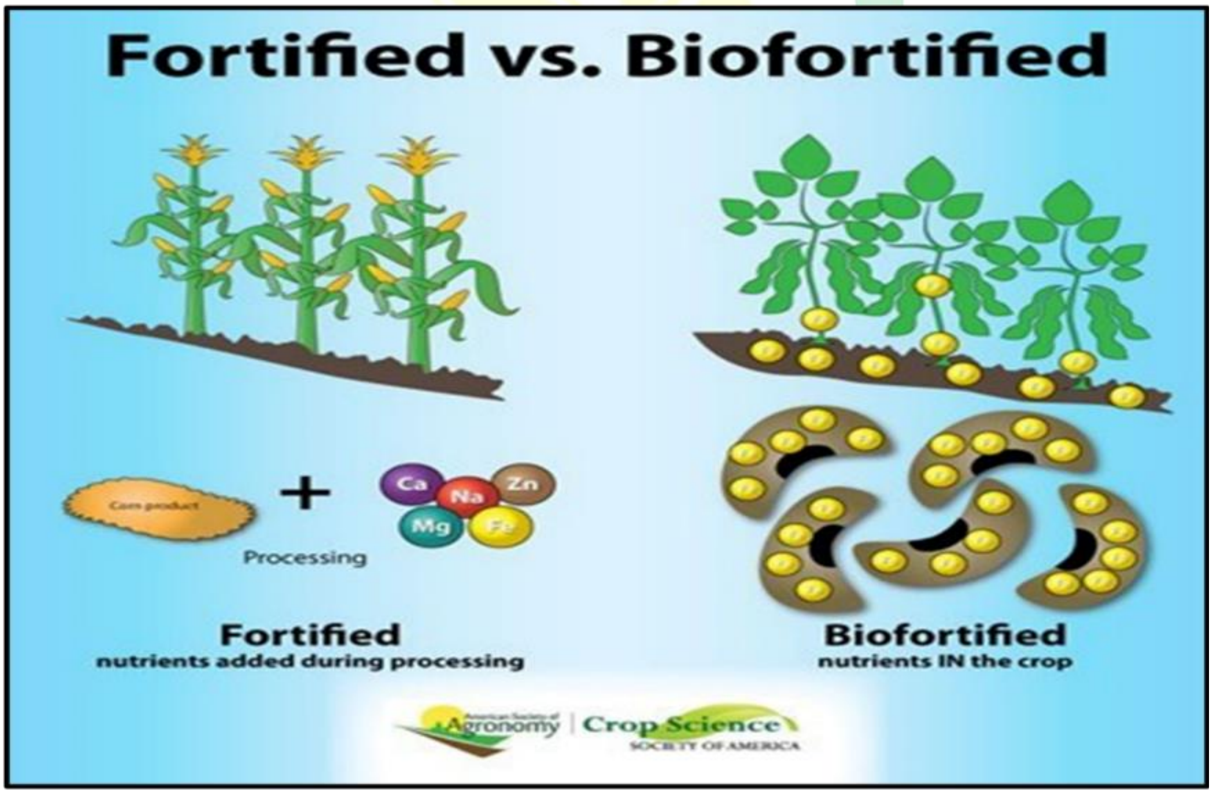
- **Chlorophyll production** – Helps in formation and maintenance of chlorophyll
- **Part of protein** – As iron is a part of protein helps in formation of amino acids
- **Oxygen carrier** – During respiration act as oxygen carrier
- **Catalase in N_2 reductase** – Helps in nitrate reductase

BIOFORTIFICATION:

- Greek word "bios" means "life"
- Latin word "fortificare" means "make strong"
- Biofortification is the process of enrichment of food crops that are rich in bio available micronutrients, such as vitamin A, zinc and iron through agronomic practices, conventional plant breeding or modern biotechnology.

Biofortification is a relatively new intervention to improve human nutrition worldwide, with a special emphasis on the populations of poor and developing countries. There are several ways to improve the nutritional value of food crops. The basic goal of biofortification is to reduce mortality and morbidity rates related to micronutrient malnutrition and to increase food security, productivity, and the quality of life for poor populations in developing countries.

Biofortification could provide a range of certain micronutrients for people who don’t have access to other interventions. As staple foods are comparatively cheap and accessible to the majority of people, the biofortification of staple crops is a primary target. Although the efficiency of biofortification is not comparable to food supplementation, it can still help reduce the micronutrient intake gap and increase the daily intake of vitamins and minerals throughout a person’s life and this may have significant impact on human health by reducing malnutrition. Indeed, improved micronutrient concentrations in several crops.



1. Cross Breeding: This technique has been used since the 1700s, it's when you take two sexually compatible crops and cross pollinate them to produce a hybrid. Some examples are the plumcot (plum and apricot), tangelos (tangerine and grapefruit), the limequat (lime and kumquat) and most famously the rabbage (cabbage and radish).

2. Mutagenesis: Mutations (muta) are genetic changes that can switch, add, or delete nucleotides (those A, T, G and C bases), these genetic changes can sometimes lead to new/enhanced traits which is why plant breeders sometimes induce (genesis) these genetic changes using radiation or chemicals. This technique in the first half of the 20th century. For example, radiation was used to produce a deeper color in the red grapefruit.

3. Protoplast Fusion: It's actually when you take two plant cells which have their hard cell walls removed (Protoplasts) and you add a chemical called polyethylene which allow the two cells to stick together. Once they are stuck together basic chemicals are added to help the two cells combine and exchange genetic information to create a hybridized plant cell (fusion). It's much like cross breeding, except it's done in a lab.

4. Polyploidy: We, humans, are diploid animals, which mean we have two sets of homologous 13 chromosomes. Polyploidy have more than one, and the induction of polyploidy is used by plant breeders to control reproduction. Introducing polyploidy by soaking seeds in colchicine can either make sterile crosses fertile, like the Triticale (hybrid of wheat and rye), or sterilizes crops, like watermelon, to make seedless strains.

5. **Genome Editing:** This process has the ability to cut, replace or insert genes within the seed cells using "molecular scissors" called nucleases enzymes which have the ability to loosen, remove and add nucleotides. These nucleases are artificially engineered to accurately place in desired genes, or traits, into the genome of the crop. Herbicide tolerant canola was created using this technique to help famers control weeds.

6. **Transgenisis:** When genes from one crop are incorporated into another crop. Since the genetic code is readable by all living organisms, this means that the genes introduced will code for the same proteins as it did before. There are many ways to introduce these new genes, like using agrobacterium to carry it into the genome, or using electricity.

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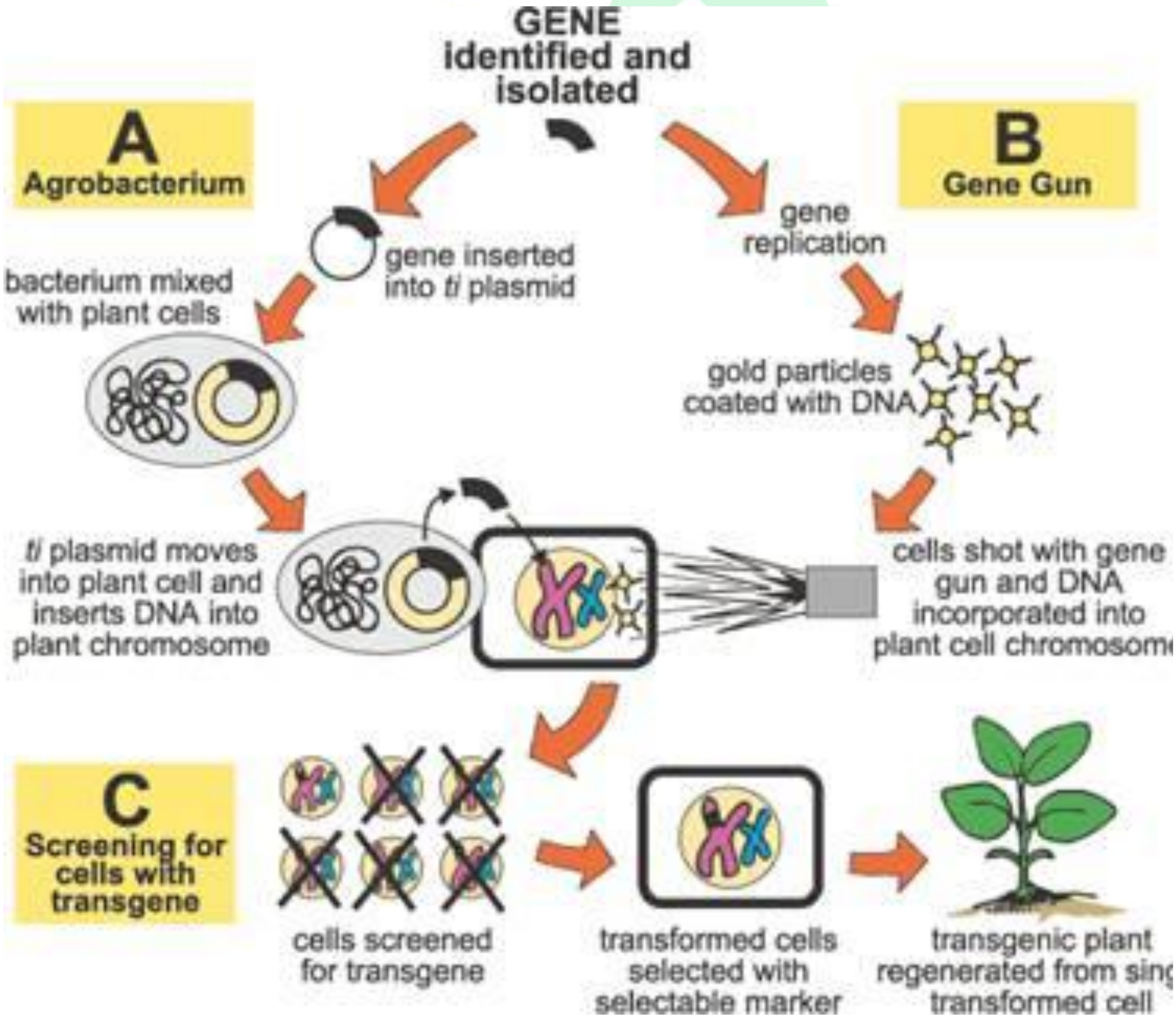
2. GENETIC ENGINEERING

Genetic engineering methods can be used to increase the trace element content of staple foods such as cereals and legumes, which can be achieved by insertion of genes with the ability to produce the desired nutrients that are typically deficient. It may involve the identification and insertion from another source, or deletion of a gene to improve the desired trait like micronutrient density. This may be achieved by the introduction of genes that code for trace element-binding proteins, over expression of storage proteins already present or the expression of other proteins that are responsible for trace element uptake into plants.



3. AGRONOMIC BIO-FORTIFICATION

Agronomic biofortification is the application of micronutrient-containing mineral fertilizer to the soil and/or plant leaves (foliar), to increase micronutrient contents of the edible part of food crops.

Nongenetic measures to improve the micronutrient concentrations of food plants could be more efficient and several strategies and measures can be adopted to increase micronutrient concentrations in the edible parts of food plants. These include management practices, fertilization of target elements and improving soil organic matter to increase nutrient availability in soil and its uptake by roots. There is evidence that agronomic biofortification not only increases yields but also the nutritional quality of staple crops. Micronutrient fertilization is most effective when using a combination of inorganic and organic fertilizers, highlighting the importance of integrated soil fertility management. Fertilizer application is an immediate and effective route to enhance trace elements concentrations in crops; nevertheless, genetic biofortification may be more cost effective in the long term. Selenium fertilization in Finland has already been adopted, and its impact on increasing selenium concentrations in Finnish foods and optimum dietary intake by humans has been reported. The biofortification of crops with vitamins through agronomic measures is not feasible; however, agronomic measures have shown enormous potential to increase mineral concentrations.

Foliar fertilization is based on the application of nutrients directly on the plants leaves. Absorption occurs either via cuticular or via stomatal pathway. Nutrient absorption via stomata can be further enhanced by using surfactants. Recently, nutrients in the form of microparticles (< 4 µm) were launched on the market. These are expected to have improved ability to be absorbed and utilized in the plant tissues. Application with surfactant improves absorption of microparticles by stomatal pathway. Mobility of compounds within the plant tissues is of great importance, because it improves utilization of nutrient applied.

Conclusion

Biofortification stands as a transformative solution in the global effort to reduce micronutrient malnutrition, particularly the widespread deficiencies of iron and zinc. By leveraging scientific advances in plant breeding, agronomic practices, and modern biotechnological tools, biofortification offers a sustainable and cost-effective pathway to enhance the nutritional quality of staple crops. This approach not only improves human health outcomes such as better immune function, cognitive development, and maternal health but also reinforces food systems that are resilient and inclusive. As the demand for nutrient-dense food continues to rise, the integration of biofortified crops into agricultural and public health strategies will be crucial.

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Biofortified Vegetables: Enhancing nutrition through breeding- The role of breeding in increasing nutrient content in vegetable to combat malnutrition

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Biofortified Vegetables: Enhancing Nutrition Through Breeding

Malnutrition remains one of the most pressing global health challenges, affecting millions of people, particularly in developing countries. While protein and calorie deficiencies are often highlighted, micronutrient deficiencies—such as a lack of vitamins and minerals—also play a significant role in undernutrition. In particular, deficiencies in vitamin A, iron, zinc, and folate can lead to a range of health issues, including impaired immune function, stunted growth, and cognitive delays. One innovative solution to combat malnutrition is the development of biofortified vegetables, which are cultivated to have increased levels of essential nutrients through plant breeding.

What is Biofortification?

Biofortification is the process of breeding crops to increase their nutritional value. It focuses on enhancing the micronutrient content of food crops, such as vitamins and minerals, to improve the health and well-being of individuals, particularly those in areas with limited access to a varied diet. The goal is to improve the nutritional quality of commonly consumed staple crops and vegetables, making them more nutritionally dense without relying on expensive supplements or external inputs like fertilizers.

Biofortification can be achieved through traditional breeding, modern genetic engineering, or a combination of both. In vegetables, the primary goal is to enhance the content of vitamins (such as provitamin A), minerals (such as iron, zinc, and calcium), and other beneficial compounds (like antioxidants and phytochemicals).

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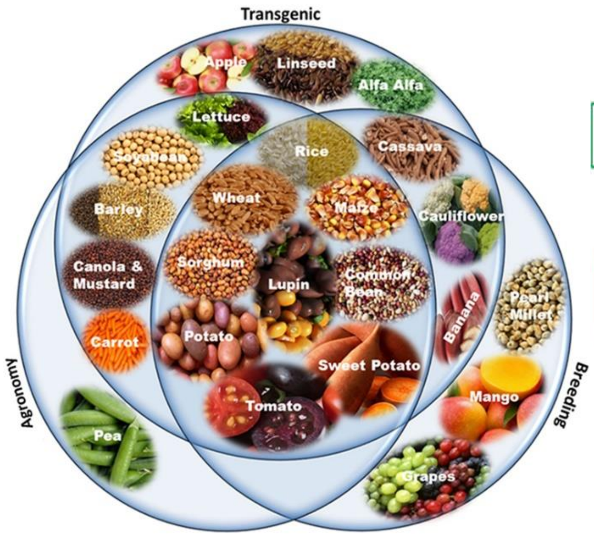

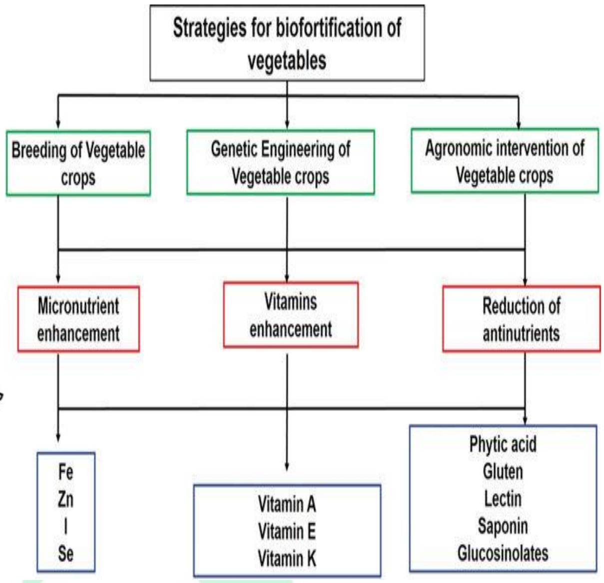

The Role of Breeding in Increasing Nutrient Content in Vegetables

Plant breeding plays a crucial role in developing biofortified vegetables. The process involves identifying and selecting plants that naturally have higher levels of specific nutrients and then crossbreeding them to enhance those traits in future generations. Several breeding techniques can be employed to achieve the desired nutrient content, including:

1. **Traditional Crossbreeding**: This involves selecting plants with high nutrient content and cross-pollinating them over multiple generations to concentrate desirable traits. Over time, breeders can create new vegetable varieties with higher levels of essential vitamins and minerals.
2. **Genetic Engineering and Genome Editing**: With advances in biotechnology, genetic engineering tools like CRISPR and transgenic approaches allow for more precise modifications in plant genomes. These techniques can directly introduce genes responsible for nutrient production, making it possible to create vegetables that are richer in essential nutrients. For example, introducing genes that increase the synthesis of provitamin A (beta-carotene) in carrots or spinach can help combat vitamin A deficiency.
3. **Marker-Assisted Selection (MAS)**: This technique uses molecular markers linked to the presence of specific genes for desirable traits. By identifying these markers, breeders can more quickly select plants with enhanced nutrient levels, significantly speeding up the breeding process.
4. **Natural Variation Exploitation**: Researchers can also search for natural variations in the genetic makeup of vegetables that lead to higher nutrient concentrations. Once these variations are identified, they can be bred into new varieties, making it easier to develop biofortified crops that require minimal intervention.

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Examples of Biofortified Vegetables

1. **Golden Potato**: In regions where vitamin A deficiency is prevalent, researchers have developed biofortified potato varieties that contain higher levels of provitamin A (beta-carotene). These potatoes are particularly useful in areas where people rely on potatoes as a dietary staple but do not have access to other sources of vitamin A, such as leafy greens and yellow/orange vegetables.
2. **Vitamin A-rich Carrots**: Carrots are naturally rich in beta-carotene, but through breeding, the concentration of this vital nutrient has been increased in some carrot varieties. This helps in addressing vitamin A deficiency, particularly in developing countries where carrots are an essential part of the diet.
3. **Iron-fortified Spinach**: Iron deficiency is one of the most common micronutrient deficiencies worldwide, leading to anaemia, fatigue and weakened immune systems. Researchers have developed spinach varieties with higher iron content through biofortification. This helps improve iron intake, especially in regions where meat and other iron-rich foods are not readily available.
4. **Zinc-enriched Beans**: Zinc is crucial for immune function and growth, yet millions of people, especially in sub-Saharan Africa and South Asia, suffer from zinc deficiency. By breeding beans with higher levels of zinc, researchers have developed varieties that can help combat this deficiency in regions where beans are a key protein source.
5. **Folate-enhanced Broccoli**: Folate, or vitamin B9, is essential for cell growth and development, particularly in pregnant women. Biofortified broccoli, which contains higher levels of folate, can help improve the nutrition of populations at risk of folate deficiency, thus reducing birth defects and promoting healthy pregnancies.




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Benefits of Biofortified Vegetables

1. **Improved Health Outcomes**: By increasing the nutrient content of widely consumed vegetables, biofortification provides a cost-effective way to combat malnutrition and related health problems. For example, biofortified vegetables can reduce the incidence of vitamin A deficiency, which is linked to blindness, weakened immunity, and even death, particularly among children under five.
2. **Sustainable and Accessible Solution**: Biofortified vegetables can be grown using traditional agricultural practices, making them accessible to smallholder farmers without requiring significant investments in fertilizers, pesticides, or special equipment. This makes biofortification a sustainable and affordable solution for improving nutrition in low-income countries.
3. **Food Security**: Enhancing the nutritional value of staple crops and vegetables helps ensure that people receive essential nutrients, even in situations where food availability is limited. Biofortified vegetables can be a key component of a diversified, nutrient-dense diet, reducing reliance on costly imported supplements or fortified foods.

Challenges in Biofortification

1. **Consumer Acceptance**: One of the primary challenges to the widespread adoption of biofortified vegetables is consumer acceptance. Some consumers may be skeptical of genetically modified or biofortified crops, either due to concerns about health, environmental impacts, or cultural resistance to altered crops.
2. **Regulatory Hurdles**: In many countries, the regulatory approval process for genetically modified crops can be lengthy and complex. These regulations can slow down the development and distribution of biofortified crops, particularly those created through genetic engineering.
3. **Economic Access**: While biofortified vegetables can be grown by smallholder farmers, their availability and accessibility may still be limited by socioeconomic factors. In some cases, it may be necessary to subsidize or promote biofortified crops to ensure they reach the people who need them most.

Conclusion

Biofortified vegetables represent an innovative and sustainable approach to combating malnutrition and improving global health. Through the power of plant breeding, we can develop vegetables that are rich in essential nutrients, helping to reduce the burden of micronutrient deficiencies and improve the health of populations worldwide. While challenges remain in terms of acceptance, regulation, and access, biofortification holds great promise as a tool to enhance nutrition and achieve food security in the face of global malnutrition crises. As research and development in this field continue to advance, biofortified vegetables will play an increasingly vital role in promoting health and well-being across the globe.

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Emerging Pests in Agriculture: Climate Change and Evolving Threats

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Abstract

The rapid emergence and spread of insect pests pose significant threats to crop yields, biodiversity, global trade, and migration. In India, pest infestations contribute to an 18–20% reduction in agricultural productivity. A review of recent literature highlights that several species, including *Helicoverpa armigera* (American bollworm), *Nilaparvata lugens* (brown planthopper), *Plutella xylostella* (diamondback moth), *Sesamia inferens* (pink stem borer), *Bemisia tabaci* (whitefly), *Macrosiphum miscanthi* (wheat aphid) and *Spodoptera frugiperda* (fall armyworm) have emerged as major pests across diverse cropping systems. Several anthropogenic factors, including excessive fertilizer use, indiscriminate pesticide application, widespread adoption of high-yielding and hybrid cultivars and shifting cropping patterns have altered pest dynamics, leading to resistance, resurgence, and secondary outbreaks. Despite that, One of the main reasons, that has usually been overlooked by us, for the changing status and scenario of insect pest species is climate change. Addressing these challenges requires ecologically sustainable Integrated Pest Management (IPM) strategies that are climate-resilient and research-driven. Strengthening such approaches is essential to safeguarding agricultural productivity and ensuring long-term food security.

Keywords: Insect pests, agricultural productivity loss, pest resistance, climate change impact, Integrated Pest Management (IPM), anthropogenic factors

Introduction

Climate change is causing global shifts in temperature patterns, precipitation dynamics, and the frequency of extreme weather events. It is well known that climate change has a significant impact on crop yields in the global agricultural sector (**Lobell and Field, 2007**), and this trend is likely to continue in the future also (**Beddington *et al*., 2012**).

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Beyond direct effects on crop yields, climate change is also influencing the distribution, severity and emergence of crop pests, i.e. 'any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products' (**FAO, 2013**) on a global scale (**Juroszek and von Tiedemann, 2011**). Moreover, shifting climatic conditions are facilitating the emergence of invasive species in new regions, further threatening global food security and ecosystem stability. According to FAO estimates, pests cause up to 40% of global crop losses annually. Additionally, plant diseases impose an economic burden exceeding $220 billion per year, while invasive insect species contribute to losses of at least $70 billion annually (**FAO, 2021**). In the absence of effective monitoring and management strategies, minor pests may become major agricultural threats (**Hellmann *et al*., 2008**). The rising severity of these biotic stresses highlights the need for integrated pest management and climate-resilient agricultural strategies.

Climate change and the emergence of new pest threats in India

Changing climatic conditions have significantly influenced insect dynamics within crop ecosystems, leading to the increase of certain species to the status of major or key pests. Insect species that are likely to move to newer areas as invasive pests, will also become an important threat to crop production, and food security as they will likely find better climatic niches in the new areas. In the absence of natural enemies in the new habitats, invasive species are likely to cause more damage than they would under normal circumstances. The insect pests that have emerged as or are likely to emerge as key or serious pests due to climate change are tabulated in Table 1.

How is climate change impacting plant pests?

Insects are highly susceptible to climate change due to their strong dependence on environmental conditions for development, reproduction and survival including both pest species and their natural enemies (**Bale *et al*., 2002**). Their relatively short generation times and high fecundity enable rapid adaptation to changing climatic conditions, making them more responsive to environmental shifts compared to plants and vertebrates.

Table 1. Insect pests that have emerged and are likely to emerge as key or serious insect pests (Sharma, 2016)

Insect pest	Scientific name	Crop
Diamond back moth	*Plutella xylostella*	Cauliflower, Cabbage
Wheat aphid	*Macrosiphum miscanthi*	Wheat, Barley, Oats
American bollworm	*Helicoverpa armigera*	Cotton, Chick pea, Tomato etc.
Beet armyworm	*Spodoptera exigua*	Chick pea in Southern India
Pink stem borer	*Sesamia inferens*	Maize, Sorghum, Wheat
Fall armywurm	*Spodoptera frugiperda*	Maize
Whitefly	*Bemisia tabaci*	Cotton, Tobacco
Pod sucking bugs	*Clavigralla spp.*	Pigeon pea
Spotted pod borer	*Maruca vitrala*	Pigeon pea, Cow pea
Brown plant hopper	*Nilaparvata lugens*	Rice
Green leaf hopper	*Nephotettix spp.*	Rice
Gall midge	*Orseolia oryzae*	Rice
Sugarcane aphid	*Ceratovacuna lanigera*	Sugarcane
Mealy bugs	*Paracoccus marginatus*	Several field & horticultural crops

1. Impact of climate change on insect pest distribution and population dynamics

Rising temperatures may enhance insect overwintering, facilitating their expansion into higher latitudes (**Hill & Dymock, 1989**). Climate-driven shifts in crop cultivation will further influence pest distribution (**Parry & Carter, 1989**). Notable examples include the projected northward migration of *Heliothis zea* in North America, increasing maize infestations (**EPA, 1989**), and the potential invasion of *Helicoverpa armigera* and *Maruca vitrata* into northern Europe. *H. armigera* has already established in Brazil and may spread to North America (**Czepak *et al.*, 2013**). Higher temperatures accelerate insect development, reducing time to reproductive maturity and driving rapid population growth.

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2. Impact of climate change on expression of resistance to insect pests

Host plant resistance is a vital component of sustainable pest management; however, climate change may modify insect-plant interactions, potentially compromising resistance mechanisms (**Sharma, 2012**). For example, resistance to sorghum midge, observed in India, deteriorates under the high humidity and moderate temperatures in Kenya (**Sharma *et al*., 1999**). Climate change is expected to exacerbate the impact of insect pests, particularly those that exploit weakened host plants experiencing stress due to suboptimal climatic conditions and a lack of adaptive mechanisms. Additionally, shifts in climate may facilitate the emergence of new pest problems by promoting the cultivation of susceptible crops or cultivars that lack resistance to prevailing pest pressures. The development and deployment of climate-resilient cultivars have been proposed as an adaptive strategy to mitigate these challenges (**Parry & Carter, 1989**).

3. Risk of introducing invasive alien species

Biological invasions are driven by environmental changes, including climate shifts and altered biotic and abiotic factors (**Dukes & Mooney, 1999**). Globalization, trade, and rapid transportation further increase the risk of exotic species introductions, threatening biodiversity and ecosystem stability. The Convention on Biological Diversity (CBD) identifies invasive alien species as a major driver of biodiversity loss, imposing economic burdens on agriculture, forestry, and aquatic ecosystems (**Mooney & Hobbs, 2000**). Global warming may intensify pest invasions by disrupting phenological events, making temperate plants more vulnerable, while climate-induced shifts could promote insect-susceptible crops, increasing pest risks (**Fitter & Fitter, 2002; Gregory et al., 2009**).

4. Impact of climate change on pest outbreaks

Climate variability has escalated the frequency and severity of insect pest outbreaks, causing substantial crop losses. The outbreak of the sugarcane woolly aphid (*Ceratovacuna lanigera*) in Karnataka and Maharashtra during 2002–03 caused yield reductions of up to 30% as given in table 2. These recurring infestations have increased plant protection costs, further burdening farmers by diminishing profit margins (**Joshi and Viraktamath, 2004**).

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Table 2. Recent insect pest outbreaks in India

Insect-pest	Host	Region	Probable reason	Impact of pest outbreak	Reference
sugarcane woolly aphid (*Ceratovacuna lanigera*) Zehntner	Sugarcane	Sugarcane belt of Karnataka and Maharashtra	Abnormal weather patterns and Insecticide misuse	30% yield losses	Joshi, and Viraktamath, 2004
Papaya mealybug (*Paracoccus marginatus*)	Papaya	Tamil Nadu, Karnataka, Maharashtra	-do-	Significant yield losses	Tanwar *et al*., 2010
Mealybug (*Phenacoccus Solenopsis*) Tinsley	Cotton	Cotton growing belt of the country	Recent abnormal weather patterns , Insecticide misuse and Changed cropping environment (introduction of Bt cotton)	30-40 % yield losses	Dhawan *et al*., 2007
Plant hoppers (*Nilparvata lugens*)	Rice	North India	Abnormal weather patterns and Insecticide misuse	Crop failure (more than 33000 ha area)	IARI News, 2008; IRRI News, 2009

5. Increased incidence of insect vectored plant diseases

Climate change is expected to increase the incidence of insect-transmitted plant diseases by expanding vector ranges and accelerating their reproduction (**Sharma *et al*., 2005**). Rising early-season temperatures have been associated with increased potato viral diseases due to the early arrival of virus-bearing aphids, the primary vectors in Northern Europe (**Robert *et al*., 2000**).

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6. Reduced effectiveness of biological control agents

Biological control is a key component of integrated pest management, maintaining ecological balance. Natural enemies of insect pests, including predators, parasitoids, and pathogens, are highly sensitive to climatic extremes such as temperature fluctuations, wind, and precipitation. Changes in rainfall patterns can influence pest-natural enemy interactions, creating complex dynamics. While prolonged humidity may favour entomopathogenic fungi, drier conditions can reduce their efficacy (**Newton *et al*., 2011**). Additionally, climate change may disrupt host-parasitoid relationships, as higher temperatures can shorten host vulnerability periods, limiting parasitoid survival and reproduction (**Gutierrez, 2008**).

How to overcome these issues?

1. Breeding Climate-Resilient Varieties
2. Rescheduling of Crop Calendars such as crop rotation and planting time
3. GIS Based Risk Mapping of Crop Pests
4. Screening of Pesticides with Novel Mode of Actions

Conclusion

Climate change is a key driver in the emergence and proliferation of agricultural pests, altering their distribution, population dynamics, and interactions with host plants. Rising temperatures, shifting precipitation patterns, and extreme weather events are facilitating the expansion of insect pests into new regions, reducing the effectiveness of natural enemies, and increasing the incidence of insect-vectored plant diseases. Additionally, climate-induced changes in crop cultivation and the introduction of susceptible cultivars further exacerbate pest-related challenges. To mitigate these evolving threats, an integrated approach incorporating climate-resilient crop varieties, enhanced biological control strategies, and adaptive pest management practices is essential. Proactive monitoring and research will be critical in developing sustainable solutions to safeguard global agricultural productivity and food security in the face of a changing climate.

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BUTTERFLY PEA JELLY: A MODERN TWIST ON NATURAL DELIGHTS

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Abstract

The butterfly pea flower (*Clitoria ternatea*), native to tropical Asia, is renowned for its vibrant blue, purple, or white blossoms, attributed to the presence of anthocyanins, particularly ternatins. These anthocyanins exhibit potent antioxidant properties, contributing to the flower's medicinal benefits, including anti-inflammatory, antidiabetic, and neuroprotective effects. Despite its health-promoting attributes, the utilization of butterfly pea in value-added products remains limited. This study explores the development of butterfly pea flower jelly as a functional food product, leveraging its natural pigmentation and bioactive compounds. The jelly preparation involves infusing the petals in water to extract the blue pigment, followed by the addition of a gelling agent, sugar, and an acidulant to achieve the desired texture and flavor. The resulting jelly not only offers a visually appealing dessert but also retains the antioxidant properties of the flower. Storage trials indicate that the jelly maintains its quality for up to three months under ambient and refrigerated conditions, suggesting its potential as a shelf-stable product. From an agricultural perspective, cultivating butterfly pea flowers offers farmers a low-cost, high-value crop with the opportunity to produce a unique product that enhances income and promotes sustainable practices. In conclusion, butterfly pea flower jelly represents a harmonious blend of traditional knowledge and modern food innovation, offering a functional, eco-friendly, and economically viable product that aligns with current consumer trends favoring natural and health-conscious foods.

Keywords: Butterfly pea flower, *Clitoria ternatea,* Natural food coloring, Anthocyanins, Ternatins, Antioxidant properties, Functional foods

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Introduction

The butterfly pea flower (*Clitoria ternatea*) is a perennial herbaceous plant, native to tropical Asia but widely distributed in many countries. Belonging to the family Fabaceae, this striking plant is best known for its vivid blue, purple or white flowers which are often used as natural dye, in herbal teas, or as a culinary ingredient. The use of food colourant in food products is important in increasing product appeal (Baskaran et al., 2019). Natural jelly candies with high antioxidant properties and medicinal properties are not commercially available at low cost.

Objectives:

- To use eco-friendly and locally sourced butterfly pea flower to support sustainable practices.
- To utilize the butterfly pea flower as a natural food colouring to produce visually appeaing jelly.
- To identify the antioxidant properties of butterfly pea flower and their potential health benefits.

Health benefits:

Butterfly pea flower which have health benefits like improves digestion, eyesight, lowering blood pressure and make the skin to glow (Oguis g et al., 2019). There are different types of bioactive compounds found in *Clitoria ternatea* which are Anthocyanin compounds, flavonoids, glycosides, steroids, resins and phenols. These bioactive compounds of the plant help with Anti- diabetic activity, Antioxidant activity, Antibacterial activity, Anti-inflammatory activity and Analgesic activity (Lakshmi et al 2014).

Clitoria ternatea is rich in anthocyanin compounds and the pigment of Butterfly pea flower is deep blue colour.. Therefore, it is used as a food colorant in the food industry. Anthocyanin is one of the most unstable food colorants found in nature and its stability depends upon temperature, pH and other enzymatic activities (Poh 2019). Most importantly, the anthocyanin present in the Butterfly pea flower in the form of polyacylated anthocyanin also known as Ternatins which is one of the stable forms of anthocyanin. Anthocyanin can play the role of antioxidant activity and antimicrobial activity which help to protect against several health issues like cancers, diabetics and cardiovascular diseases (Lakshan et al.2019).

Need for the jelly:

Nowadays scientists are researching blue pea flower for making different medicines, due to the presence of many functional compounds in this plant. Currently, blue pea flower tea is available in the market and it has been a trending beverage in Asian countries. Specially some popular companies of Asia launched a special edition of cold beverages using blue pea flowers. But only a few value added products are available in the market.

Butterfly pea jelly:

Natural jelly candies have high antioxidant properties and medicinal properties are not commercially available at low cost. Butterfly pea jelly is a vibrant naturally coloured dessert made from the flowers of the butterfly pea plant known for its striking blue hue. The jelly is made by infusing the petals of the butterfly pea flower in to water which is then combined with a gelling agent to achieve a firm jelly like structure. The jelly is not only visually stunning but also boasts mild, earthy flavour. Additionally it has gained popularity for its potential health benefits such as its antioxidant properties.

Methodology:

Collect the fresh butterfly pea flowers and wash thoroughly.

↓

Then boil the flowers in water and strain the suspension and set aside.

↓

Dissolve gelatin powder in a blue suspension and mix it well and allowed it to set.

↓

Add sugar and water in a pan, allow to boil.

↓

Squeeze lemon to the sugar solution and add the prepared jelly mixture to it.

↓

Mix well and pour into the required mould.

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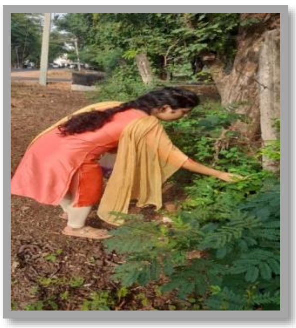
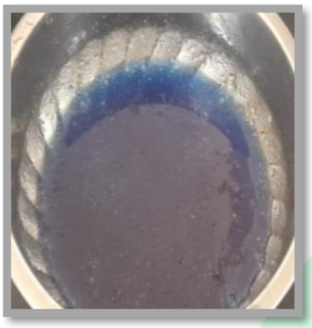
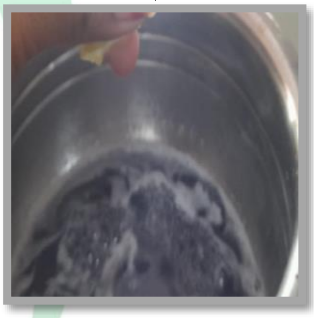


Collection of flowers

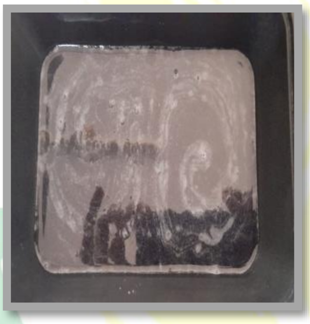


Extraction of juice

Adding gelatin



Squeeze lemon at the time of boiling



Pour in to the container

Cut in to small pieces

Final product

Storage:

The PET bottles containing butterfly pea flower jelly after cooling were stored for 3 months at both ambient 30ºC and refrigerated temperature 5 ºC.

Farmers point of view in generating income:

- Low cost, High- Value crop

  Butterfly pea flowers are hardy, require minimal care, and can thrive in various climates.

- Value added product for higher profit

  Higher selling price: Instead of selling raw flowers, processing them into jelly increases their market value.

  Unique selling point: Butterfly pea flower jelly stands out due to its natural blue colour and health benefits. (Rich in antioxidants)

  Longer shelf life: unlike fresh flowers, jelly can be stored longer, reducing waste.

For farmers, producing Butterfly pea flower jelly is a great value added business opportunity that enhances income while promoting sustainability and health conscious products.

Conclusion:

Butterfly pea flower (*Clitoria ternatea*) jelly is a delightful fusion of natural beauty, health benefits and culinary creativity. Its striking blue to purple hues, derived from anthocyanins , not only make it visually appealing but also provide antioxidant properties that promote overall well being. This jelly is easy to prepare, versatile and pairs well with various ingredients such as coconut milk, honey or citrus for a unique flavor experience. Whether enjoyed as a refreshing dessert or an elegant addition to a special occasion, butterfly pea flower jelly is a perfect blend of tradition and innovation in the world of culinary arts.

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Critical Care in Neonatal Hypoglycemia: Strategies for Prevention and Management

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Abstract

Neonatal hypoglycemia is a significant and life-threatening condition in calves, often leading to severe complications, including weakness, coma, and increased mortality rates. The condition arises from inadequate energy reserves, exacerbated by factors such as disease, maternal rejection, improper nutrition, and environmental stress. It is closely linked to neonatal diarrhea, endotoxemia, and sepsis, which further deplete glucose levels. This article examines the causes, risk factors, and prevalence of hypoglycemia in neonatal calves, highlighting essential prevention strategies such as proper colostrum management, balanced nutrition, temperature regulation, disease control, and stress reduction. Implementing these strategies can significantly improve calf survival, health, and productivity, contributing to economic sustainability in the dairy and beef industries.

Introduction

Neonatal hypoglycemia is a common and dangerous condition that severely impacts calf survival and development. It primarily results from insufficient energy reserves at birth, which is often exacerbated by factors such as inadequate nutrition, health problems, environmental stress, and maternal rejection. Mortality rates due to neonatal conditions, including hypoglycemia, vary significantly by region. In India, for example, calf mortality ranges from 5% to 25%, with higher rates in winter and among male calves, who suffer from lower immunoglobulin absorption (Kaushik et al., 1980; Singh et al., 1980). In tropical regions of Asia, mortality rates typically range from 10% to 30%, due to poor colostrum intake, infections, and environmental stress (Sangwan et al., 1985; FAO, 2021). On a global scale, neonatal calf mortality averages 8% to 15%, with diarrhea, pneumonia, and dystocia being the most common causes (FAO, 2021; WHO, 2021).

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Hypoglycemia is often associated with diseases like neonatal diarrhea, endotoxemia, and sepsis, which increase the rate of glucose depletion and energy loss. If left untreated, it can cause severe neurological damage and even result in death. Addressing the causes and risk factors of neonatal hypoglycemia, along with applying effective prevention and management techniques, is crucial for improving calf health, reducing mortality, and boosting farm productivity.

Table 1: Neonatal Calf Mortality Rates by Region

Region	Mortality Rate (%)	Key Causes
India	5 - 25%	Immunoglobulin deficiency, seasonal effects
Asia	10 - 30%	Poor colostrum intake, infections, environmental stress
Worldwide	8 - 15%	Diarrhea, pneumonia, dystocia

(Sources: Kaushik et al., 1980; Sangwan et al., 1985; FAO, 2021; Bellows et al., 1987; Fink, 1980; Singh et al., 1980; WHO, 2021; ICAR, 2022)

Blood Profile in Normal vs. Hypoglycemic Calves

Table 2: Blood Parameters in Normal and Hypoglycemic Calves

Parameter	Normal Range	Hypoglycemic Condition
Blood Glucose (mmol/L)	4.4 – 6.9	< 2.0
Cortisol (ng/mL)	20 – 50	> 70
Beta-hydroxybutyrate (mmol/L)	< 0.5	> 1.0
Lactate (mmol/L)	< 2.5	> 5.0
Insulin (µIU/mL)	5 – 25	< 5

(Sources: ICAR, 2022; FAO, 2021; WHO, 2021)

Causes of Hypoglycemia in Calves

Newborn calves possess limited energy reserves and are highly vulnerable to hypoglycemia, especially when affected by disease, congenital defects, injury, or maternal rejection. It is often observed in critically ill calves, particularly those suffering from sepsis, diarrhea, or endotoxemia, which accelerate energy depletion. Research shows that neonatal hypoglycemia is common in calves with systemic inflammatory response syndrome (SIRS), and its presence is associated with poor prognosis and a higher likelihood of mortality.

Prevention Strategies for Neonatal Hypoglycemia

Preventing neonatal hypoglycemia requires a combination of management practices and early intervention. Essential preventive strategies include:

1. **Ensuring Adequate Colostrum Intake:** One of the most vital steps in preventing hypoglycemia is ensuring sufficient colostrum intake within the first few hours after birth. Colostrum is rich in both immunoglobulins and glucose, crucial for a calf's health. It should be administered within the first two hours of life to maximize absorption. A recommended amount is 10–15% of the calf's body weight within the first 24 hours.
    - **High-Quality Colostrum:** Use colostrum with a minimum of 50 g/L IgG to guarantee adequate immune protection.
    - **Alternative Feeding Methods:** If the calf is too weak to suckle, colostrum should be provided via a bottle or esophageal feeder to ensure proper intake.

2. **Transition to a Balanced Milk-Based Diet:** After colostrum feeding, calves should be transitioned to a balanced milk-based diet to sustain energy levels. High-quality milk replacers or whole milk should be given 2–3 times daily, depending on the calf's nutritional requirements. Energy supplements such as oral glucose or electrolyte solutions may be beneficial for weak calves to meet their energy needs.

3. **Temperature Control and Warmth:** Cold stress can lead to increased metabolic activity and higher glucose consumption. To prevent hypoglycemia, it is important to keep calves warm and dry.
    - **Warm Housing:** Provide warm housing with deep straw bedding and windbreaks, especially in cold conditions, to prevent heat loss.
    - **Body Temperature Monitoring:** Ensure the calf's body temperature stays above 37°C (98.6°F), as hypothermia can worsen glucose depletion.

4. **Monitoring High-Risk Calves**

   Certain calves, such as premature, twin, or weak ones, are more susceptible to hypoglycemia and need extra care. If signs of hypoglycemia like lethargy, uncoordinated movements, or difficulty suckling are observed, immediate intervention with oral energy supplements or intravenous glucose should be administered to stabilize blood glucose levels and prevent further complications.

5. **Hygiene Management and Disease Control:** Neonatal diseases like diarrhea quickly deplete energy stores and contribute to the onset of hypoglycemia. To reduce pathogen exposure:
   - **Hygiene Practices:** Maintain clean, dry calving areas to minimize the risk of infections. Regularly disinfect pens and equipment.
   - **Vaccination:** Ensure timely vaccinations for common infectious diseases like rotavirus and E. coli, and isolate sick calves to prevent spreading.
6. **Reducing Stress:** Stress is a significant factor in hypoglycemia development, as it impairs feeding and nutrient absorption. To reduce stress:
   - **Gentle Handling:** Handle calves gently, especially during the first few days, to minimize stress and promote health.
   - **Avoid Overcrowding:** Ensure that calves have enough space to access milk, warmth, and shelter, as overcrowding can lead to inadequate nutrition and increased stress.

Conclusion

Neonatal hypoglycemia in calves is a preventable condition that requires careful management of nutrition, environment, and health. Ensuring timely colostrum intake, providing balanced nutrition, regulating temperature, and reducing stress are crucial steps in minimizing hypoglycemia risks. Early detection and prompt intervention are essential to improve calf survival rates. Implementing these prevention strategies not only enhances calf health but also supports the productivity and sustainability of dairy and beef farming operations.

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Dragon fruit: an emerging fruit crop in the food processing industries in India

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ARTICLE ID: 09

Abstract:

Dragon fruit, a nutrient-rich superfruit, has gained commercial significance in India due to its vibrant colors and adaptability to tropical climates. Despite limited research, its cultivation has expanded across multiple states, with notable growth in area and production since 2018. The global market for dragon fruit is projected to reach USD 12.6 billion by 2033, driven by demand in Asia, Europe, and the US. Rich in vitamins, antioxidants, and essential fatty acids, it offers probiotic, anti-inflammatory, and antiangiogenic benefits. Its pulp, seeds, and peel are used in juices, wines, jams, and cosmetics, making it a high-value crop with applications in nutrition, medicine, and beauty, promoting sustainability and global trade.

(**Key words:**Antioxidants, Global market, Probiotic, Sustainable farming, Value-added products**)**

Introduction:

A new superfruit in India, dragon fruit is valued as a high-value, economically viable crop because of its delicious black seeds, nutrient-rich flesh, and vivid hue. Originally from Mexico and Central and South America, the crop has garnered attention for cultivation because to its capacity to adapt to India's tropical environment, however there is currently little study on it. Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat, and Karnataka account for the majority of the fewer than 200 hectares now under cultivation. Dragon fruit cultivation provides significant profitability despite early investment expenditures due to its great export potential and rising domestic demand (Sharma *et al*.2021). Under ideal cultural conditions, the crop bears fruit beginning in the first year and reaches maximum output in three to five years. It is a viable choice for sustainable fruit production and export as it is hardy, grows well in a variety of agroclimatic situations, and does best in soils that drain well.

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Nutritive value:

Dragon fruit has trace levels of several different nutrients. One fruit that is rich in nutrients is the dragon fruitand it has a very low-calorie count. It's also a fantastic source of Fiber, iron, and magnesium.

Table 1: The average nutritional content of 100 grams of raw dragon fruit

Nutrient	Amount (per 100 g)	Daily value (%)
Water	87 g	-
Protein	1.1 g	2.1
Fat	0.4 g	-
Carbohydrates	11.0 g	3.4
Fiber	3 g	12
Vitamin B1 (Thiamine)	0.04mg	2.7
Vitamin B2 (Riboflavin)	0.05mg	2.9
Vitamin B3 (Niacin)	0.16mg	0.8
Vitamin C (Ascorbic Acid)	20.5mg	34.2
Calcium (Ca)	8.5mg	0.9
Iron (Fe)	1.9mg	10.6
Phosphorus (P)	22.5mg	2.3

(**Source:** Sharma *et al*.2021)

Dragon fruit's demand in international markets:

It is expected that the worldwide mythical serpent natural product advertise would increment from USD 7.4 billion in 2023 to USD 12.6 billion by 2033 at a compound yearly development rate (CAGR) of 5.5%. The demand in Asia, especially among Chinese people, is fueled by traditional ideas about the fruit's good fortune symbolism. People emphasize on the fruit's shape for fire worship. Japanese customers, on the other hand, value flavour above quantity (Sharma *et al*.2021). The high price of dragon fruit is still promising in Europe, where consumers are open to novel goods, and as costs come down and nutritional value rises, it should become more widely accepted by consumers. Although it is becoming more popular in the mainstream market, dragon fruit is mostly enjoyed by Asian and Vietnamese populations in the US. Florida and California are expanding their cultivation to satisfy the growing demand.

Global output of dragon fruit: Dragon fruit was brought to tropical South Asian nations in 1990 as a commercial crop in southern Mexico, Guatemala, and Costa Rica. Mexico, Ecuador, Thailand, Malaysia, Indonesia, Vietnam, China, Mexico, Colombia, Nicaragua, Australia, and the United Statesare among the many nations now experiencing substantial fruit production and growth. Apart than its impromptu global expansion, its production and marketing statistics are scarce.

Based on factors including productivity, planted acreage, market availability, and monetary factors, dragon fruit is categorized as a smallFruit from the tropics. According to recent statistics released by various private groups and available data from specific nations, the production of dragon fruit has expanded dramatically over the last ten years. Vietnam, China, and Indonesia are the three main nations that supply93 percent or more of the dragon fruit harvested globally.On a range of 55,419 hectares, Vietnam produces more than half (51.1%) of the world`s commodities, with annually yields extending from 22 to 35 metric tons (MT) per hectare. More than a million metric tons of mythical beast natural product are delivered in Vietnam (Sharma *et al*.2021).

Table 2: Production of Dragon Fruit worldwide

Country	Production area (ha)	Production (MT)	Productivity (MT ha^{-1})
Vietnam	55,419	10,74,242	22-35
China	40,000	7,00,000	17.5
Indonesia	8,491	2,21,832	23.6
Thailand	3,482	26,000	7.5
Taiwan	2490.6	49,108	19.7
Malaysia	680	7,820	11.5
Philippines	485	6,062.5	10-15
Cambodia	440	4,840	11.0
India	400	4,200	8.0-10.5
USA	324	5,832	18.0
Australia	40	740	18.5
South Africa	12	100	8.3
Total	1,12,264	21,00,777	-

(Source: Sharma *et al*.2021)

Production of Dragon Fruit in India:

Dragon fruit was brought to Indiatowards the end of the 1990s, andfrom 2005 to 2017, its growing spread over many states, growing from 4 to 400 hectares. It was first cultivated in southern and eastern states like as Karnataka, Maharashtra, and Gujarat. Today, it is also grown inMadhya Pradesh, Uttar Pradesh, Haryana, Punjab, and Rajasthan, and the Northeast. Production increased to about 12,000 MT across 3,000–4,000 hectares by 2020, mostly due to commercial measures that were implemented after 2018. With a production of 1.5–3.1 MT/ha, 80% of the 3,085 ha are made up of plantings under 18 months of age, whilst mature plantations produce 8–13.5 MT/ha. Drip irrigation and good agronomic techniques may increase yields to 4.5 MT/ha in the first year, between 7.5 and 10 MT/ha in the second year and between 16 and 24 MT/ha in the third (Sharma *et al*.2021).

(Table 3:Vital winged serpent fruit-producing states (zone, efficiency, and generation gauges, 2020)

Major States	Total Area (ha)	New area (ha) 80%, A1*	Productivity of A1 (MT/ha), P1	Production in A1 (MT), Y1	Old Area (ha), A2	Productivity (MT/ha) of A2*, P2	Production in A2 (MT), Y2	Total production (MT) (Y1+Y2)
Andhra Pradesh	140.4	112.3	1.5	168.5	28.1	10.2	286.5	455.0
Telangana	80.9	64.8	1.8	116.6	16.2	10.0	161.9	278.4
Tamil Nadu	121.4	97.1	2.2	213.7	24.3	12.0	291.4	505.1
West Bengal	303.5	242.8	2.1	509.9	60.7	11.0	667.7	1177.7
Maharashtra	323.8	259.0	3.1	802.9	64.8	13.5	874.1	1677.1
Karnataka	485.6	388.5	3.0	1,165.5	97.1	12.4	1,204.4	2,369.9
Gujrat	1,214.1	971.3	2.2	2,136.8	242.8	8.0	1,942.5	4,079.3
Rajasthan	38.4	30.8	1.5	46.1	7.7	8.0	61.5	107.6
Meghalaya	174.0	139.2	2.8	389.8	34.8	11.4	396.8	786.6
Other	202.3	161.9	1.5	242.8	40.5	10.7	433.9	676.7
Total/ average	3,084.6	2,467.7	2.2	5,792.6	616.9	10.7	6,320.7	12,113.4

Valorized Products from Dragon Fruit: Processed horticultural products have extended shelf life, stable costs, and year-round availability. Dragon fruit, once ornamental, is now valued for its colorful bracts, reddish-white flesh, and nutrient-rich seeds. Processing reduces wastage and adds value to both edible and non-edible parts. The pulp, peel, seeds, flower buds, dried flowers, and stems all possess significant nutritional and functional properties. The low-calorie pulp is rich in calcium, phosphate, vitamin C, phytoalbumins, and soluble fibers. Red and pink varieties serve as natural colorants (Wakchaure *et al*. 2023). The peel, over one-third of the fruit's weight, contains betacyanins, phenolics, and fibers with anticancer, antidiabetic, and antioxidant effects. Seeds offer essential polyunsaturated fatty acids like linoleic and linolenic acids, aiding digestive and glycemic health. These diverse benefits have attracted interest from researchers, nutritionists, and extension workers, highlighting dragon fruit's rising significance in food processing and health industries.

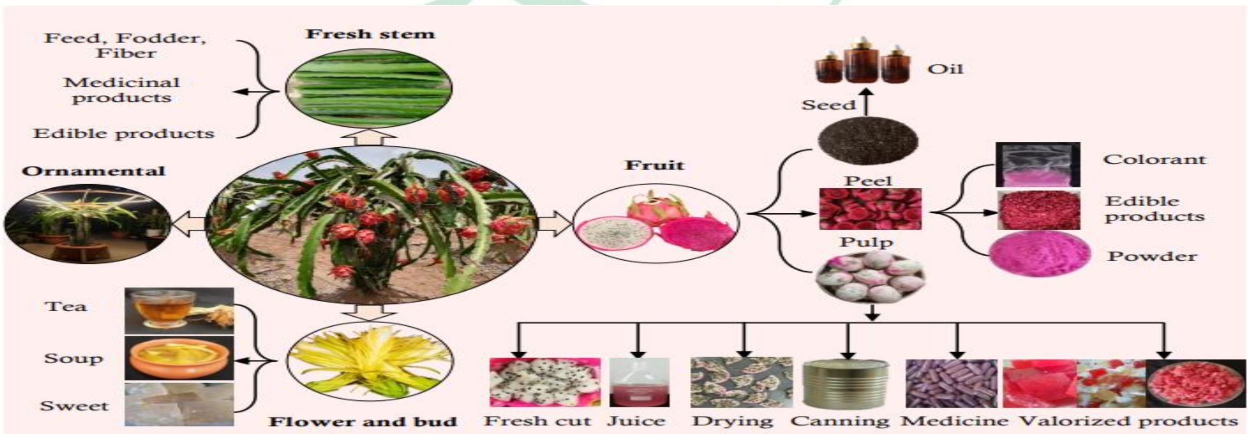

Fig.1. Diagrammatic representation for the creation of a valuable product from dragon fruit

(Source:Wakchaure *et al*. 2023)

Dragon fruit processing:
Dragon fruit is processed to create value-added goods including juices, jams, peel canndy, peel jelly, and wine, among others, which increase the fruit's nutritional content and commercial potential.

1. **Preparation of Jam:**

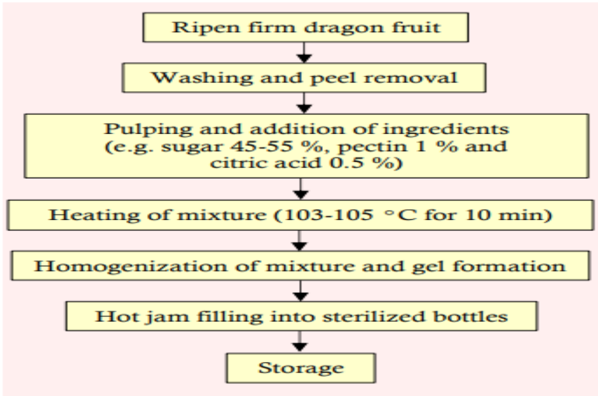

Fig.3. Flow chart of Dragon fruit jam

(Source: Wakchaure *et al*. 2023**)**

2. **Preparation of Fruit Juice:**

Fig.4. Making juice out of dragon fruit

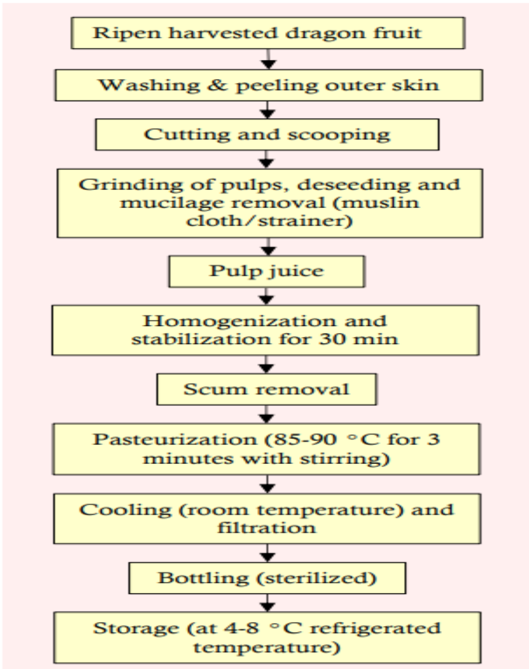

Fig.5. Dragon fruit juice preparation process flow chart

(Source: Wakchaure *et al*. 2023**)**

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Preparation of peel candy:

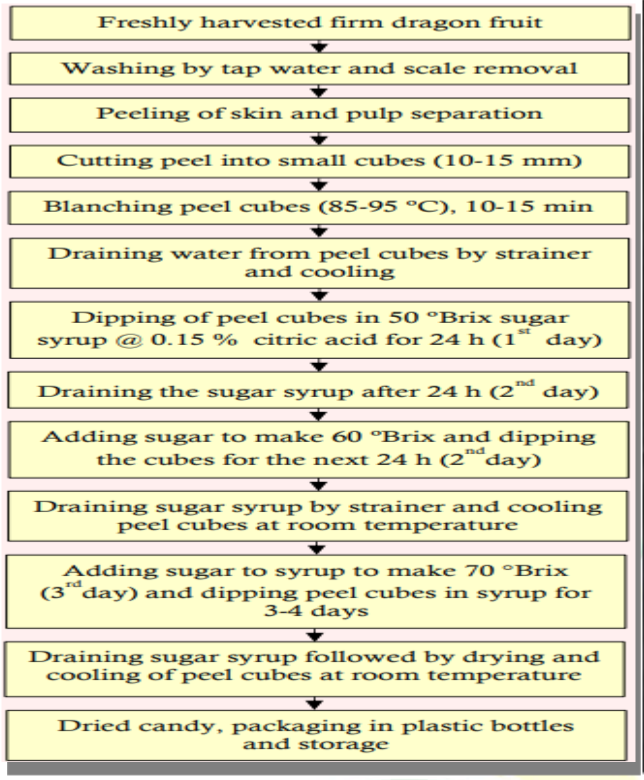

Fig.6. Process flow chart for preparation of peel candy. **Fig.7. Dragon fruit peel candy**

(**Source:** Wakchaure *et al.* 2023)

Preparation of Peel jelly:

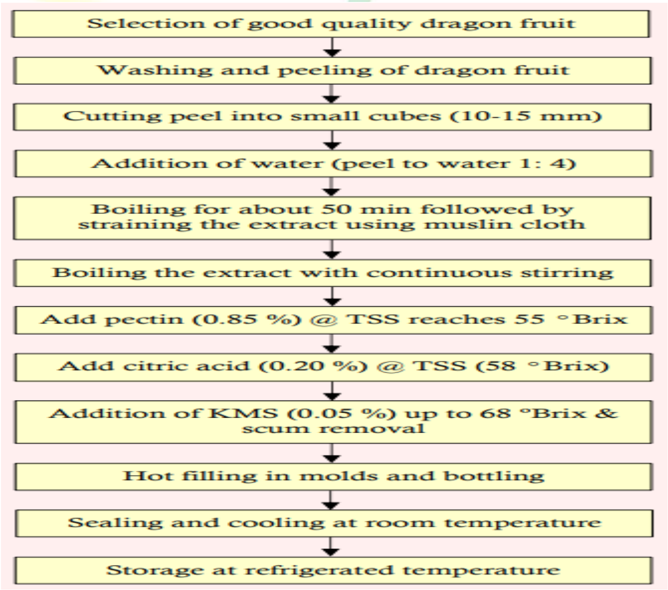

Fig.8. Dragon fruit peel jelly **Fig.9. Process flow chart for preparation of peel jelly**

(**Source:** Wakchaure *et al*. 2023)

Dragon Fruit Wine:

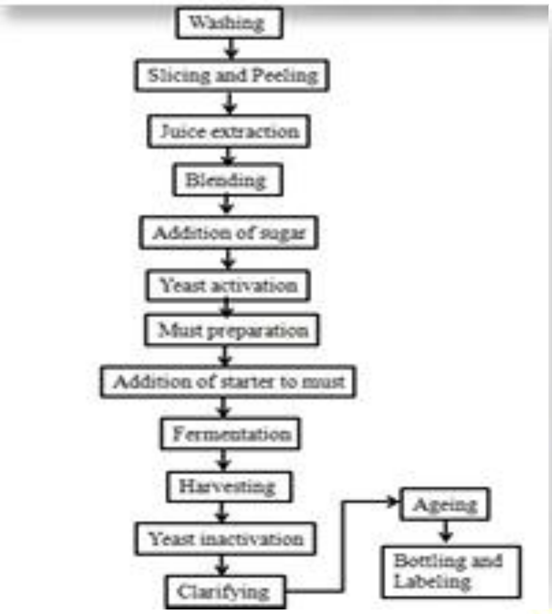

Fig.10. Process flowchart for dragon fruit wine

Fig.11. Wine made with dragon fruit

(Source: Lokesh *et al.*(2024).*Futuristic Trends in Agriculture Engineering & Food Sciences***3**(15);396-410**)**

Cosmetic and Pharmaceutical Items:

Dragon fruit is regarded as a superfood because of its high nutraceutical content, which includes minerals (calcium, potassium, salt), antioxidants, betalains, vitamins (C, B1, B2, B3), polyunsaturated fatty acids, and dietary fibers. Anti-inflammatory, antiangiogenic, and probiotic qualities are among the medical and cosmetic advantages of its pulp, peel, and seeds. Dragon fruit helps bone and kidney health, vision, memory, immune system function, wound healing, cardiovascular health, and protects colon cancer.

Medication: Tablets containing fruit extract, body oil, nourishing gel, and liquid extract

Cosmetic Items: Shampoo, shower gel, beauty cream, hair color, lip balm, facial kit, and cosmetic scent

Conclusion:

A very valuable crop with considerable economic viability, dragon fruit has gained popularity in both home and foreign markets. Its many health advantages, which include vitamins, antioxidants, and vital fatty acids, make it an even more alluring superfood. The crop is becoming more profitable because to rising output in India and growing demand worldwide, especially in Asia, Europe, and the US. Due to its versatility in a variety of agroclimatic settings and its potential for value-added goods like juices, jams, and cosmetics, dragon fruit is a viable option for both sustainable farming methods and economic expansion. Because of its many uses, it is regarded as a vital crop in international trade.

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Fruits and vegetables marketing

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ARTICLE ID: 10

Indian farmers depend heavily on middlemen, particularly in fruits and vegetables marketing. The producer and consumer often get a poor deal with the marketing system and the middlemen control the market, but do not add much more value on products. India is the second largest producer in the world after China in fruits and vegetables production. India's share in the world production of fruits and vegetables stands at11.38% and 11.78% respectively. Horticultural crop area is about 27.23 million hectres with the production of 331million metric tonnes till the end of 2023.This tremendous increase in the area and productivity of Horticultural crops(Fruits and Vegetables)was witnessed because of the support by the Government of India through various schemes such as Scheme no. I(Commercial Horticulture) and Scheme no-II(Cold Storage),Technology development and transfer for provided Production of Horticulture crops, Market information services, Recognition of Horticulture nurseries, Horticulture promotion services etc. In Assam facilities on Cold storage system for keeping fruits and vegetables are still lacking behind. Secondly, in most of the places of rural areas in Assam for Horticultural crops are not yet seen such type of facilities. So the concerned workers in this line should take this matter very seriously. Therefore, it can be well said that, Horticulture play a very special role in the Indian economy providing regular employment to the rural people of India; that also help to boost up the GDP rate in the country itself.

At present, India is among the 15th leading exporters of fruits in the world. For getting a healthy life; many rural farmers have concentrated on production of fruits and vegetables with different crops at present. The diverse soil and climate conditions in the country makes it possible to cultivate a wide variety of fruits and vegetables in various parts of our country.

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APEDA promotes India's fruits and vegetables export to different countries in the world. According to APEDA; the important exporting fruits are Grapes, Mangoes, Pomegranates, Oranges, Banana etc and various vegetables are onion, potato, green-chillies, okra, spinach, cabbage, cucumber, beans, pumpkin etc. APEDA provides financial assistance to the registered exporters to promote agro-based exports. This assistance can be used for market development, Infrastructure development and quality development of various fruits and vegetables. APEDA is also mandated with the responsibility of export promotion and development in fruits and vegetables and their products, Meat and Meat products, Poultry and Poultry products. Quality is very much important aspects in exporting fruits and vegetables to other countries in the World. If it is found defective; then automatically it is discarded by the foreign customers.

Marketing of Horticultural crop is complex especially because of perishability, seasonality and bulkiness of products. Market infrastructure should be improved through storage facilities, cold chain facilities for keeping the quality of fruits and vegetables for a few days. The market integration and efficiency; can also be improved through various acceptable ways and means; including a good marketing information system, internet and good telecommunication facilities at the marketing places. Poor efficiency in the marketing channels and inadequate marketing infrastructures are believed to be the root causes of not only high and fluctuating consumer's price; but also to a little of the consumer rupee reaching in to the hand of farmer. The yield per hectare of fruits varied from 0.4MT in Himachal Pradesh to 25.6MT in Tamilnadu with a national average of 12MT. Similarly, the yield per hectare of vegetables varied from around 4.5MT in Mizoram to 27.10MT in Tamilnadu with a national average of 15.2MT. From this data it is quite evident that Tamilnadu is the most productive state in terms of production of both fruits and vegetables in recent years.

Agricultural marketing is continued to be plagued by many market imperfections such as inadequate infrastructure, Lack of scientific grading system, defective weightment, lack of quality measurement in fruits etc. There are about 4,000 numbers of regulated markets working with fruits and vegetables trade. But the market regulation has been successful only in some areas. Thus it is observed that the basic points are not yet achieved to a desired level in our country. A large number of whole sale markets are yet to be brought under the preview of market legislation.

Regulating markets are the first step to be considered for improvement in business of fruits and vegetables in our country. Indian farmers usually depend heavily on middlemen, especially in fruits and vegetables marketing. A particular relation between producer/Growers and Consumer followed in most of the states of our country. This is also called a channel. Where a producer is directly linked with Pre-harvest contractor/Consumer. This is followed by the commission agent, Retailer and Consumer.The popularity of this network system was introduced in Fruits and vegetables markets in different states in this country. Pre-harvest contractor approaches near to the Farmers/Growers for purchase of their products just before it's maturity. This kind of business is very much common in Tamilnadu, Karnataka, Punjab, J&K, Haryana, UP, Andhra Pradesh, Uttarakhand, Rajasthan etc.for purchasing Grapes, Pomegranates, Mangoes, Bananas, Oranges, Mixed Vegetables, Potatoes, Tomatoes, Apple, Green chillies, Mandarine, Grapes etc. Cultivations of Fruits and Vegetables is further noted as labour intensive crop than cultivating cereal crops and offer additional post harvest cost for adding valuation. Fruits and Vegetables are not solely utilized for domestic consumption and processing into

various products viz prickles, preserves, sauces, Jam, Jelly, squashes etc. but likewise substantial quantities are exposed in fresh and processed form, bringing around extensively demanded Foreign Exchanges for this country. Such type of crops gives meaningful impact on National Economy in the present business scenario. Let us also think for strengthening the co-operative marketing societies for the benefits of farmers of Assam and other states of this country. The advancement made by the co-operative marketing institution so far through remarkable aspects is not wholly satisfactory.

Co-operatives have yet to be taken over a substantial part of the entire agricultural production scenario. Thus, it is very much important that these co-operatives needs to be evolved right now and along the accurate line of work.

Further, it is discussed that distribution of fruits and vegetables plus the food grain needs to be managed efficiently and properly in case of marketable demand of a particular area. Most of the Family labors are also engaged with the productions of Fruits and vegetables in our country; which comes to about 78% farmers dealing with this type of production scenarios.

Time to time, Marketing channels are also modified according to the product, Organizational position and the producing country's competition, trade policies in the International marketing system. The vegetables are often consumed by people of our country together with rice grain(cooked), Chapatis , dal etc. So the domestic demand specially for food grain should be integrated in to whole country if it is possible .This calls for the demanding of conditions on-pricing, trading, distributions and movement of agricultural yields within the country in future. At present, the horticultural crops in the country covers 23.60million hectres of land i.e. 7% of the gross cropped area and contribute to about 18-20% of the gross value of Agricultural output. India's share in world fruit production is very significant, the largest producer of Mango and Banana in the world and 5th position in the production of Pineapple; 6th position in the production of Oranges,10th position in the production of Apple. In case of Vegetables, India secured 1st position in Cauliflower, 2nd in Onion production, 3rd in Cabbage and 6th in potato production in the world. The diverse climatic condition in the country gives greater chances to produce more vegetable & fruits at a time. If flood comes in one or two states every year that cannot lower down the whole economic scenario of this country at a time and same goes for drought also. Nowadays climate resilient technologies are available. Drought tolerant varieties are also available in some areas of our country. A few numbers of vegetables could be grown well in some productive zones in India with minimum water holding capacity of soil. Currently, many recommendations are available in the internet for improving the marketing of fruits and vegetables with in this country. So scientists, social workers, concerned farmers should look in to this matter positively in future.

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Government Initiatives to Ensure Nutrition Equity in India

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Introduction

India's food security programs encompass a diverse array of initiatives designed to combat hunger and malnutrition across different demographic segments. These initiatives include national schemes and local efforts targeting vulnerable populations such as low-income families, children, and the elderly. As of July 2024, the Central Pool holds 608.75 lakh metric tonnes of foodgrains, significantly surpassing the stocking norm of 411.20 lakh metric tonnes. This surplus guarantees sufficient supplies for the Targeted Public Distribution System (TPDS), various Welfare Schemes (CWS), and other government programs across the country.]

The National Food Security Act (NFSA)

The National Food Security Act legally entitles up to 75% of the rural population and 50% of the urban population to receive subsidized food grains through the Targeted Public Distribution System. NFSA covers approximately 81 crore beneficiaries across India, including 16 crore women, reflecting its commitment to empowering women. This broad coverage encompasses both Priority Households (PHH) and Antyodaya Anna Yojana (AAY) categories, ensuring subsidized food grains are accessible to a substantial portion of the population.Top of FormBottom of Form

Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY)

The Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY) was launched with the specific purpose of ameliorating the hardships faced by the poor and needy due to economic disruptions caused by the COVID-19 pandemic in the country.

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The Central Government has decided to extend the Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY) for an additional five years, starting from January 1, 2024. This initiative will provide free food grains to approximately 81.35 crore beneficiaries.

PM POSHAN (POshan SHAkti Nirman) Scheme

The PM POSHAN Abhiyaan aims to tackle hunger and improve education by enhancing the nutritional status of children in Government and Government-aided schools, and by encouraging regular school attendance among disadvantaged students.

Hon'ble Prime Minister has approved the continuation of the national scheme of PM POSHAN in Schools for the five-year period 2021-22 to 2025-26 with the financial outlay of ₹ 54061.73 crores from the Central Government and ₹ 31733.17 crore from State Governments & UT administrations. Central Government will also bear additional cost of about ₹ 45000 crore on food grains. Therefore, the total scheme budget will amount to ₹ 130794.90 crore.

The Antyodaya Anna Yojana (AAY)

The Antyodaya Anna Yojana (AAY) is an essential social welfare initiative aimed at ensuring food security for the most vulnerable segments of society. Program now supports over 8.92 crore individuals. Notably, among these beneficiaries, more than 2 crore are women, highlighting the program's focus on addressing the needs of female participants and ensuring their access to critical resources.

This targeted approach not only addresses the nutritional needs of the poorest families but also emphasizes the importance of including women in social welfare schemes, ensuring that their needs are met and they are empowered in the process. The substantial number of female beneficiaries reflects the program's commitment to reaching out to all segments of society and making a positive impact on their lives.

Overview of Rice Fortification in India

Fortified rice is rice that has been enhanced with essential vitamins and minerals to improve its nutritional value. Since the 2019-20 fiscal year through March 31, 2024, approximately 406 lakh metric tonnes of fortified rice have been distributed through the Public Distribution System (PDS).

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Government Actions on Price Stability and Affordability

The Government has utilized the Price Stabilization Fund (PSF) to manage price volatility in essential agri-horticultural commodities, ensuring that individuals,especially those from lower-income groups, do not face difficulties due to fluctuating prices.

The onion buffer has increased from 1 LMT in 2020-21 to 7 LMT in 2023-24. This strategic approach aims to stabilize prices and prevent significant fluctuations that could otherwise impact the availability and affordability of these essential items.

Bharat Dal was launched in July 2023, converting Chana stock into subsidized Chana dal priced at Rs.60 per kg for 1 kg packs and Rs.55 per kg for 30 kg packs. Additionally, Bharat Atta and Bharat Rice are available at subsidized rates of Rs.27.50 per kg and Rs.29 per kg, respectively, through NAFED, NCCF, and Kendriya Bhandar.

From Crisis to Confidence: India's Role in Global Food Security

India is a food surplus country today, standing as the largest producer of milk, pulses, and spices, and the second largest producer of food grains, fruits, vegetables, cotton, sugar, tea, and farmed fish. There was a time when India's food security was a global concern, but now, the country is providing solutions for global food and nutrition security. Reflecting on this transformation, India's shift to a global leader in food and nutrition underscores its valuable experience in food system transformation, which is poised to benefit the Global South.

Conclusion

The implementation of food security measures in India is pivotal in addressing the complex challenges of hunger and malnutrition. By focusing on increasing agricultural productivity, refining food distribution systems, and stabilizing prices, India aims to ensure that food is both available and affordable for all its citizens.

Targeted initiatives, such as subsidized food schemes and special programs for vulnerable groups, are crucial in mitigating the effects of economic disparities and ensuring equitable access to essential food resources. Furthermore, integrating nutritional support and adopting sustainable practices not only addresses current food security needs but also lays the groundwork for a resilient and long-term solution.

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Impact of Agricultural Policies on Food Security

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ABSTRACT

Agricultural policies play a crucial role in shaping food security by influencing food production, availability, access and affordability. These policies include subsidies, trade regulations, price controls, support for farmers land use strategies, investment in agricultural infrastructure and promotion of climate-resilient practices. When well-designed, agricultural policies can enhance food security by promoting sustainable farming, stabilizing markets, improving rural livelihoods, and ensuring that food reaches both rural and urban populations. However, poorly implemented or inequitable policies may lead to inefficiencies, market distortions, environmental degradation, or neglect of smallholder farmers, potentially worsening food insecurity. In the context of climate change, global trade fluctuations, soil depletion, resource scarcity and population growth, the role of agricultural policies has become even more critical. Governments and international bodies must strike a balance between supporting local producers, encouraging innovation, promoting equitable access and maintaining fair, inclusive food distribution systems. This explores how policy decisions impact the long-term stability and resilience of food systems and highlights the importance of inclusive, adaptive and forward-thinking agricultural strategies to ensure sustainable food security for all, especially in vulnerable and low-income communities worldwide.

Introduction

Food security, defined as the ability of all people to access sufficient, safe, and nutritious food at all times, is a critical component of global development and human well-being. Agricultural policies, implemented at national and international levels, play a pivotal role in determining how food is produced, distributed, and consumed.

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These policies can influence food availability, affordability, and accessibility, which are key pillars of food security. While well-designed agricultural policies can enhance food production, stabilize markets, and protect vulnerable populations, poorly conceived policies can exacerbate food insecurity, environmental degradation and inequality. This essay explores how agricultural policies affect food security across different regions, analysing both positive and negative outcomes, and highlighting the need for inclusive, sustainable, and climate-resilient policy frameworks in a changing world.

The Role of Agricultural Policies in Enhancing Food Security

Agricultural policies directly influence food production by shaping the incentives, inputs, and infrastructure available to farmers. In many countries, government subsidies for seeds, fertilizers, and irrigation have contributed to increased crop yields and improved food availability. For example, India's Green Revolution policies in the 1960s and 1970s, which focused on high-yield crop varieties and subsidized inputs, transformed the country from a food-deficient nation to a net exporter of grains.

Trade policies also impact food security by determining how countries access international food markets. Liberalized trade policies can improve food availability by allowing countries to import food during domestic shortages. Conversely, export bans and tariffs can lead to price spikes and supply chain disruptions, as seen during the 2007–2008 global food crisis, when some major grain-exporting countries restricted exports to protect their domestic markets.

In addition, agricultural policies can support food security through investments in rural infrastructure, such as roads, storage facilities, and irrigation systems. These investments reduce post-harvest losses, improve market access for farmers, and enhance the efficiency of food distribution networks. Policy measures that promote research and development in agriculture also lead to innovations in crop breeding, pest control, and water management, boosting resilience and productivity.

Subsidies and Their Mixed Impact

While subsidies are often implemented to support farmers and ensure affordable food prices, they can have unintended consequences. In some cases, subsidies distort market incentives, leading to the overproduction of certain crops and underproduction of others. For instance, heavy subsidies for rice and wheat in some developing countries have led to the neglect of other nutritious and climate-resilient crops like millets and legumes. This not only affects dietary diversity but also reduces ecological sustainability.

Moreover, input subsidies—such as those for water, fertilizers, and fossil fuels—can encourage overuse of natural resources, contributing to soil degradation, water depletion, and greenhouse gas emissions. In the long term, such environmental degradation can undermine agricultural productivity and threaten food security. Reforming subsidies to prioritize sustainability and nutritional outcomes is therefore essential.

Land and Tenure Policies

Secure land tenure is another critical aspect of agricultural policy that affects food security. When farmers, particularly smallholders, have legal rights to the land they cultivate, they are more likely to invest in long-term improvements, such as soil conservation and irrigation infrastructure. Conversely, insecure or informal land tenure can discourage investment, limit access to credit, and increase vulnerability to displacement or land grabs.

In many parts of Africa and Asia, land tenure reforms have sought to provide farmers—especially women and marginalized groups—with legal recognition and protection. These reforms can improve food production and household nutrition by empowering farmers to make decisions that enhance productivity and resilience. However, in practice, implementation challenges, bureaucratic hurdles, and gender biases often limit the effectiveness of such policies.

Social Protection and Food Access

Agricultural policies also intersect with food access through social protection programs. Policies that support food subsidies, public distribution systems, and school feeding programs help ensure that vulnerable populations can afford and access adequate food. For example, Brazil's Zero Hunger Program combined food transfers with support for smallholder farmers, contributing to a significant reduction in hunger and poverty.

Conditional cash transfer programs, such as those in Mexico (Prospera) and Ethiopia (Productive Safety Net Programme), link financial support to behaviors like school attendance and health checkups. These programs indirectly improve food security by enhancing household incomes and enabling families to invest in nutritious food.

However, the effectiveness of such programs depends on proper targeting, efficient delivery mechanisms, and coordination with agricultural production. If not aligned with local food systems, these programs can create dependency or distort local markets.

Climate-Resilient Agricultural Policies

With climate change intensifying the frequency of droughts, floods, and pests, agricultural policies must now prioritize resilience. Policies that promote climate-smart agriculture—such as drought-tolerant crops, agroecological practices, and water-efficient irrigation—are essential for protecting food systems against climate shocks.

Several countries have introduced national adaptation plans that incorporate agriculture as a key sector. For instance, Kenya's Climate-Smart Agriculture Strategy and India's National Mission on Sustainable Agriculture aim to build resilience among farmers through capacity-building, insurance schemes, and support for diversified farming systems.

Incentives for agroforestry, conservation agriculture, and integrated farming systems not only improve productivity but also enhance ecological sustainability. However, the challenge lies in scaling these practices while ensuring that smallholder farmers have access to the necessary knowledge, tools, and financial resources.

Global Agricultural Policy and Food Trade

International trade policies and global institutions also shape food security outcomes. Organizations like the World Trade Organization (WTO), the Food and Agriculture Organization (FAO), and regional trade agreements influence how countries access global markets and regulate agricultural subsidies.

While trade liberalization can increase food availability by enabling the flow of agricultural products across borders, it can also expose small farmers to competition from large-scale producers in other countries. This can lead to the decline of local agricultural systems, especially if domestic policies do not offer adequate support for local producers.

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Furthermore, food-importing countries can become vulnerable to global price volatility, geopolitical tensions, and supply chain disruptions. The COVID-19 pandemic and the Ukraine-Russia conflict both highlighted the fragility of global food systems and the need for policies that balance openness with self-sufficiency.

Equity and Inclusion in Agricultural Policy

Equity is a crucial yet often overlooked dimension of food security. Agricultural policies that fail to consider the needs of marginalized communities—such as women, indigenous peoples, and landless labourers—can reinforce existing inequalities and leave vulnerable groups behind.

Women, who make up a significant portion of the agricultural labour force in many developing countries, often lack access to land, credit, extension services, and decision-making power. Policies that support gender equity—through land rights, training, and targeted support—can unlock their full potential and contribute to improved food security at the household and community levels.

Inclusive policies must also recognize the needs of youth, who represent the future of agriculture. Programs that support youth engagement in agribusiness, innovation, and sustainable farming can address both food security and rural employment challenges.

The Need for Integrated and Participatory Policy Making

Agricultural policy-making should be inclusive, evidence-based, and participatory. Farmers, researchers, civil society, and private sector actors must be involved in shaping policies that reflect local realities and aspirations. Top-down approaches often fail to address the complexities of rural livelihoods and may not gain the trust or cooperation of stakeholders.

Integrated policies that bridge agriculture, nutrition, environment, and social protection can lead to more coherent and effective outcomes. The "food systems approach," which considers the interconnections between food production, processing, distribution, and consumption, is increasingly recognized as a framework for developing holistic agricultural policies.

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Conclusion

Agricultural policies are powerful tools that shape the future of food security. When designed and implemented effectively, these policies can increase food availability, improve access, support farmers, and promote environmental sustainability. However, poorly structured policies can lead to resource depletion, inequality and heightened vulnerability to climate and market shocks. As the global population grows and climate change intensifies, the pressure on food systems will escalate, making it essential for policymakers to adopt forward-thinking, inclusive, and adaptive approaches that prioritize resilience, equity and sustainability. Supporting smallholder farmers, investing in climate-smart agriculture, reforming subsidies, securing land rights, and promoting inclusive governance are all essential components of this transformation. Ultimately, achieving food security in the 21st century will require not just producing more food, but implementing better, smarter policies—policies that are responsive to the evolving needs of people and the planet alike.

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Pulses and Oilseeds Management under Integrated Organic Nutrient Approach in Sikkim

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Abstract

Loamy and sandy soils are both suitable for growing black gramme, but well-drained sandy loam soils are the best. The nutrient requirements of a black gramme are met by organic sources such as FYM, mixed compost, poultry manure, vermicompost, oil cakes, and other commercially available biofertilizers. Mustard and rapeseed can grow in a variety of soil types, from clay loam to sandy loam, although they do best in light loam soils. Due to its leguminous nature, it requires less nitrogen than other crops. While a variety of soil types can support soybean growth, the best conditions are well-drained, fertile loamy soil that is high in organic matter. Green peas react negatively to acidity in the soil. Good development requires acid soils to be adequately limed. Nutrient requirements are not very high for peas.

Keywords: Organic nutrient management, Black gram, Soybean, Pea, Brassica, Sikkim

Introduction

Pulses comprise roughly 7–10% of the nation's overall foodgrain production and make up about 20% of the land planted to foodgrains. Although both the Kharif and Rabi seasons are used to grow pulses, over 60% of the entire production comes from Rabi pulses. Because they are both abundant sources of protein and energy that are necessary for human nutrition, oilseeds and pulses are significant in Indian agriculture. Cereals are the most important source of food for humans, followed by pulses. It is a crop that can be produced in regions that are prone to drought since it is extremely climate-resilient and water-efficient. By fixing nitrogen and encouraging soil microorganisms, it improves soil fertility. Currently, 25% of the world's pulse production comes from India. In contrast to the ICMR's recommendation of 52 grammes per day, the per capita availability of pulses was 55.9 grammes per day.

In addition to being used to extract oil, oilseeds are a great source of fat-soluble vitamins A, E, and K and are crucial for the production of a number of long-chain alcohols. Soy beans, coconut, mustard, castor, oil palm, linseed, sesame, rapeseed, groundnuts, sunflower, safflower, olive seeds, and so forth are among the main oilseed crops (Das et al., 2018).

Black gram (*Vigna mungo* var. viridis L.)

The brief length of this crucial pulse crop gives agricultural systems the chance to develop as a catch crop, sequential crop, and mixed crop. A rich source of protein (24–26%), it fixes atmospheric nitrogen, improves soil physical characteristics, and boosts biological qualities, all of which contribute to maintaining soil fertility.

Soil management

Although black gramme can be cultivated in a range of soil types, including sandy and loamy soils, well-drained sandy loam soils are the best. It can also be cultivated as a rainfed crop on heavier soils. The ideal pH range for soil is 4.7 to 7.5. Because it can withstand a little amount of alkalinity, it can also be cultivated on saline and alkaline soils.

Organic nutrient management

There aren't many organic solutions for managing nutrients. To meet a black gram's nutritional needs, organic sources such as FYM, mixed compost, poultry manure, vermicompost, oil cakes, and other commercially available biofertilizers are utilised. The addition of organic manures, such as FYM or mixed compost, at a rate of 5 t/ha improves yield in light-textured and poorly fertilised soil. Seed yield and nutrient uptake are also increased by inoculating seeds with the right Rhizobium strains. Water-soluble organic granules at a rate of 12.5 kg/ha combined with FYM, vermicompost, or mixed compost can provide extra nutrients. Fifteen days before planting a black gramme, all organic sources, such as FYM, mixed compost, and cakes, should be applied. To bring the pH of acidic soils up to 6.0, dolomite application at a rate of 2 t/ha is advised; however, soil testing may also be carried out. For best results, apply FYM at 5–10 t/ha and vermicompost at 2.5–5.0 t/ha, either separately or together (Das 2014).

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Brassica spp.

The three most significant oilseed crops are toria, mustard, and rapeseed. In addition, the oil is utilised in the tanning, medicinal, cosmetic, hair oil, and vegetable preparation industries. Glucoside sinigrin is the cause of the unusual pungency found in Brassica species' seeds and oil. By dry weight, the Brassicas contain 40% oil.

Soil management

Although they can grow in a variety of soil types, including sandy loam and clay loam, mustard and rapeseed do best in light loam soils. They are unable to withstand thick soils and waterlogging. Although plants can withstand moderate salinity rather well, neutral pH soil is best for healthy plant growth and development.

Organic nutrient management

150 kg of rock phosphate and 10 tonnes of FYM or vermicompost were applied at a rate of 3-5 t/ha during the final field preparation. Azotobacter or Azospirillum can save 20–30 kg of nitrogen per hectare. Mustard yield is significantly increased by adding vermicompost, Azotobacter, and phosphorus-solubilizing bacteria (PSB). To meet the crop's needs for micronutrients and sulphur, various kinds of oil cakes should be put to the soil at a rate of 0.5 to 1.0 t/ha. To achieve the highest toria yield, one study at the ICAR Sikkim Centre suggested applying mixed compost at a rate of 5 t/ha, vermicompost at a rate of 1.0 t/ha, neem cake at a rate of 1.0 t/ha, and dolomite at a rate of 1.0 t/ha (Das et al., 2017).

Soybean (*Glycine max* L. Merril)

It is the most significant seed legume in the world, accounting for almost two-thirds of the world's protein concentrate for animal feed and 25% of the edible oil produced worldwide.

Soil management

Although soybeans can be cultivated in a variety of soil types, the best soil for soybean cultivation is well-drained, fertile loamy soil that is high in organic matter. For soybeans, the ideal pH range is between 6 and 6.5. Particularly in its early stages, the crop is susceptible to water logging. In order to raise the pH of more acidic soils to neutrality, liming is necessary.

Organic nutrient management

Because it is a leguminous crop, it requires less nitrogen than other crops. During the last stages of land preparation, FYM (farmyard manure) should be spread and mixed into the soil at a rate of 5–10 t/ha. Green manuring, the use of biofertilizers, vermicompost, etc., should be used to meet the additional nutrient needs of crops. In a study conducted at the ICAR Sikkim Centre, soybean variety PK-1042 generated a grain yield of 3300 kg/ha after responding favourably to neem cake at 1 t/ha + mixed compost at 2.5 t/ha + dolomite at 1 t/ha.

Pea (*Pisum sativum* L.)

The most significant annual cool-season pulse crop is a self-pollinating diploid (2n=14) that is prized as a high-protein meal. It is commonly cultivated throughout the world's tropical highlands and milder temperate zones.

Soil management

Although they may be grown in any kind of soil, peas thrive in sandy loam soils that drain well since they are extremely sensitive to water logging. The soils should ideally drain well down to a minimum of 50 cm. An abundance of organic matter in the soils promotes greater growth by providing nutrients more slowly. Extremely alkaline or acidic soils do not support it. It can withstand a mild pH range of 6.0 to 7.5 in the soil. A pH of 6.5 is ideal. To improve the soil's qualities, it should be treated if the pH is below 6.0. Peas need friable soil with adequate aeration between the crumbs and lengthy sunny hours. The nitrogen-fixing bacteria that reside on the pea plant's roots depend on air to survive. In exchange for carbohydrates, bacteria trade nitrogen with the plant. Soils that do not dry out are preferred by peas. Light soil is improved and heavy clay soils are opened up with the addition of well-decomposed compost. It is quite easy and successful to grow peas if the soil conditions are appropriate (Das et al., 2020).

Organic nutrient management

Green peas are sensitive to the acidity of the soil. For healthy growth, acid soils must be adequately limed. The nutrient requirements of peas are not very high. The pea doesn't need large amounts of nitrogen because it is a leguminous crop. In the case of very light soils, apply roughly 15-20 t/ha of well-decomposed organic manure, such as compost, FYM, and/or vermicompost, at a rate of 2.5 to 3.5 t/ha, either by itself or in conjunction with FYM for the best harvest. In addition to applying manures, Rhizobium inoculum must be applied to the seed to improve nodulation, plant vigour, and grain yield. As a starting dose, the crop should first be given vermicompost, bokashe, oil cakes, or any other organic manure at a rate of 2 t/ha (Das and Avasthe 2018).

Conclusion

Their special capacity to fix nitrogen improves soil fertility, lowering greenhouse gas emissions and reliance on artificial fertilisers. Through crop rotation, the production of pulses also contributes to biodiversity conservation by creating robust and ecologically balanced agroecosystems. Because they may be used to make biofuels, livestock feed, and edible oil, oilseeds are a vital component of agriculture. They are also an excellent source of energy and protein, both of which are vital for human nutrition.

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ROLE OF MORDANTS IN TEXTILE DYEING

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Abstract

Mordants are essential to the dyeing process because they ensure that dyes are properly bonded to textile fibres, improve colourfastness, and allow for a variety of bright colors. These materials, which come in both natural and synthetic forms, improve dye absorption and stop color fading by forming a chemical interaction between the dye and fibre. While synthetic mordants like chromium and aluminium acetate produce stable and bright color effects, natural mordants like alum, tannin, and iron which are derived from plant sources and minerals offer more environmentally friendly options. Mordants also improve the sustainability of the dyeing process and make it possible for dyes to work with a variety of textiles, including synthetic and natural materials. Furthermore, the use of mordants raises health and environmental concerns and emphasizes how important they are to producing textiles that are both visually pleasing and long-lasting.

Keywords: Environmentally-friendly, Mordants, Sustainability, Long-lasting

I. Introduction

Dyeing is one of the oldest and most popular method in textile arts, used to add color and personality to fabrics. Dyeing is a process used to apply colors and their variations to fabric, enhancing its appearance and giving it visual appeal. Dyeing can be done at every stage of the manufacturing process of textile fibre, yarn, fabric, or a fully finished textile product that includes clothing and accessories. The choice of the appropriate dye and the technique for the textile material to be dyed for dyeing are the two main determinants of color fastness (Daberao, *et al*., 2016). Dyeing became a well-protected specialty because of highly skilled artisans and well-kept secret techniques. In ancient times, it was common practice to blend red, blue, and yellow dyes to create a variety of colors. Metal salts were also used to help dyes retain on the target material and to change the colors that were produced.

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Unlike wool and silk, cotton cannot be dyed directly with natural dyes; nevertheless, it can be dyed by vatting or by treating it with artificial salts called mordants (from the Latin word *'mordere'*, which means 'to bite'). These are adsorbed on the fibre and react with the dye to produce a less soluble form that is held to the fabric. Alum, potassium aluminum sulfate, as well as iron, copper, and tin salts were common ancient mordants. (Stothers, 2007). However, mordant as a chemical that can both fix itself to the fabric and mix with the dyestuff. As a result, a bond is created between the fibre and the dyestuff, enabling the fixing of some dyes that have no affinity for the fibre. By creating an insoluble mixture of mordant and dyestuff inside the fibre, the mordant helps create quicker hues when the dyes can be dyed directly (Alegbe and Uthman, 2024).

II. Types of Mordants

A mordant is a substance that is used to fix or set dyes on fabrics or fibres. It ensures that the color will remain on the cloth for a longer period of time and aids in better dye absorption. Metallic salts (such as iron or aluminium), natural mordants and synthetic mordants can all be used as mordants.

Natural mordants are derived from plant sources or minerals and are often less toxic and more environmentally friendly. This category includes:

- **Tannins**: Used for both protein and cellulose fibres.
- **Alum**: Commonly used for all types of fibres.
- **Iron Salts**: Primarily darkens colors, mainly used with plant fibres.
- **Pomegranate Rind**: Known for providing rich colors and is high in tannins. (Prabhu and Bhute, 2012).

Synthetic mordants are chemically produced substances used to fix dyes onto fibres, ensuring consistent and vibrant color results. This category includes:

- **Chrome (Potassium Dichromate)**: Produces vibrant colors but raises environmental concerns
- **Aluminium Acetate**: Preferred for cellulose fibres and helps achieve richer shades.
- **Aluminium Triformate**: Allows easier application without heat, suitable for both fibre types. (Pizzicato, *et al.*, 2023).

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III. The Role of Mordants in the Dyeing Process

Mordants ensure that the color remains on the fibre by creating a chemical interaction between the dye and fibre. They develop the color and assure that it remains bright and long-lasting by forming a chemical bond between the dye and the fibre. In the absence of mordants, dyes, particularly natural ones, may not attach to fibres as effectively, resulting fading or washing away. Mordants also increase the colorfastness of the dye, which increases the fabric's resistance to fading, washing, light exposure, and other environmental conditions. The final color can also be greatly influenced by the mordant selection; different mordants result in varied color hues, intensities, and depths.

For example, alum, can provide vibrant colors, but iron produces tones that are deeper.Mordants also improve how effectively dyes are absorbed, especially in plantbased fabrics like cotton that usually have complications bonding with dyes.Furthermore, a variety of colors can be created fro m a single dye by changing the type or concentration of mordant.Lastly, by increasing the dye's c ompatibility with various fibre types, such as cellulose fibres like cotton and linen and protein fib res like wool and silk, mordants make sure dyes cling to them correctly. For the dyer to achieve stunning, long-lasting results, mordants are necessary for fixing the dye, boosting colorfastness, influencing the final color, promoting dye absorption, and providing compatibility with different textiles (Repon *et al.*, 2024).

IV. Applications of Mordants in Dyeing

Mordants play a crucial role in dyeing by strengthening the relationship between the dye and fabric, enhancing color fastness, and allowing a range of colors. Their applications include:

i. ***Natural Dyeing***: Mordants, which use materials like alum, tannin, and iron to produce different colors, attach natural dyes to fabrics and improve color variation.

ii. ***Industrial Dyeing:*** Mordants, especially when used with synthetic fibres, assure uniformity, improve colourfastness, and improve dye absorption in large-scale production.

iii. ***Eco-friendly Dyeing:*** Sustainable, non-toxic dyeing that has a reduced environmental impact using natural mordants like tannin and alum.

iv. ***Cultural Dyeing:*** In ancient textile techniques, such as indigo dyeing, mordants are utilized to produce bright shades with cultural meaning.

v. ***Specialty Dyeing:*** Mordants produce unique colors for premium and customized textiles, including lightening and darken effects (Singh and Bharati, 2014).

V. Environmental and Health Considerations

Mordants are important for dyeing since they increase the stability and brightness of the color. Still, there are health and environmental issues with their use in dyeing. Conventional mordants such as iron, copper, and chromium are poisonous and can damage human health and ecosystems. Workers in the textile industry are exposed to these chemicals, which can cause organ damage, breathing problems, and skin irritation. Water bodies may become contaminated by dyeing process wastewater. Eco-friendly substitutes, such as natural and biodegradable mordants derived from fungi and plants, are being studied to address these problems. To reduce the negative effects of dyeing mordants on the environment and human health, guidelines, wastewater treatment, and enhanced safety procedures are also required (Manhita *et.al.*, 2011).

VI. Future Trend of Mordant in Dyeing

The textile industry is moving towards sustainable mordants, such as tannins, plant-based compound, and biopolymers, to lessen environmental pollution. Because of their toxicity, traditional mordants including copper, chromium, and aluminium are raising concerns. Natural substitutes such as tannins, plant-based compounds, and biopolymers are also being investigated. Advances in biotechnology and creative approaches to applying mordants, including supercritical CO_2, are also being evaluated. It is expected that this trend toward sustainable innovations along with efficiency will continue (Benli, 2024).

VII. Conclusion

Mordants are essential to the dyeing process because they help dyes bond to textiles in a way that produces bright, durable colors. Their application improves the fabric's durability against fading, washing, and climatic conditions by increasing color fastness. They allow dyers to produce an extensive range of colors, from bright, energetic tones to rich, deep hues, whether they use synthetic mordants like chromium and aluminium acetate or natural ones like tannin and alum. Mordants enable the suitability of colors with different fibre types, both natural and synthetic, in addition to improving dye absorption, particularly in plant-based fibres like cotton. Additionally, mordants support sustainable and environmentally friendly dyeing methods; natural mordants are favoured due to their low environmental impact. The use of mordants will continue to be crucial as dyeing methods advance in order to create fabrics that are superior, long-lasting, and visually appealing. This will contribute to sustaining cultural customs and promote the creation of creative, environmentally friendly textile options.

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The Role of Edible Coatings and Films in Modern Food Systems

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Introduction

Food is fundamental for human survival, and as time progresses, consumers are increasingly focused on the quality of their food. This growing concern has highlighted the importance of innovative packaging solutions, particularly edible coatings and films (ECFs), which are gaining prominence in biobased packaging. ECFs play a crucial role in enhancing the sensory attributes of food products and minimizing the proliferation of microorganisms, contributing to a safer and healthier environment. These sustainable materials are essential for addressing the challenges of food preservation and environmental impact. Edible films are thin sheets applied directly to food products, while edible coatings are formed on the food surface through various techniques. Both are crafted from eco-friendly and safe materials, often including proteins, polysaccharides, lipids, plasticizers, emulsifiers, and active substances such as antimicrobials and antioxidants. The use of edible coatings and films is not a novel concept but has been employed since prehistoric times, such as waxing fruits and using cellulose coatings in meat casings.

In response to increasing consumer demand for food preservation methods derived from biological sources, modified techniques utilizing ingestible biopolymers have emerged. ECFs offer a promising alternative to conventional petroleum-based plastic packaging, which are non-degradable and environmentally unfriendly. By utilizing renewable resources, edible coatings and films contribute to more sustainable food systems and can potentially reduce food waste by maintaining the freshness and safety of perishable goods. The technology for edible coating production involves several key aspects, including the preparation of the coating material and the methods used to apply it to food products.

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Edible Coating Materials

Edible coatings and films are manufactured using solutions with a mixture of different natural components. These components can include proteins, polysaccharides, and lipids, as well as other ingredients like plasticizers, emulsifiers, and active substances such as antioxidants and antimicrobials.

The selection of these materials depends on the desired properties of the coating, such as mechanical strength, barrier properties (to moisture, oxygen, CO2), and adhesion to the food surface.

•Novel film-forming ingredients from sources like root plants (cassava, potato, sweet potato) and other plants (achira flour, amylum, yam, ulluco, water chestnut) are being explored.

•The physical properties of the biopolymers used are influenced by factors like their characteristics, biochemical conformation, compatibility, relative humidity, temperature, water resistance, and application procedures.

•In some cases, nanocomposite films are being developed, which involve support networks of biological polymers.

•Tannic acid can be used as a cross-linking agent to improve the strength and mechanical properties of edible coatings and films due to covalent bonds and cross-linking with coating materials.

•Plasticizers are often added to the coating solution to increase mechanical properties. Common plasticizers include glycerol, fatty acids, sorbitol, propylene glycol, sucrose polyethylene glycol, and monoglycerides.

Methods of Applying Edible Coatings:

The technique and way of coating application are very important to ensure thorough coverage of the product and prolong shelf life. Several strategies are utilized for applying edible coatings to food products:

• Dipping (Immersion Technique): This is a widely used method where the food item is plunged into the ECF solution. It is particularly applicable for products with uneven surfaces and can result in dense coatings. The food is typically submerged for 5 to 30 seconds and then dried naturally. While simple, this method can sometimes lead to hindrance in reparation due to thick coating or solution and may weaken the food surface's outer covering.

• Spraying: This is another fundamental strategy for food covering, allowing for the creation of consistent and uniform layers.

• Brushing: Edible coatings can be applied using a brush, which is reported to give good results, particularly for beans and highly perishable fruits and vegetables like strawberries and berries.

• Extrusion: This method depends on the thermoplastic properties of the edible coating and is considered a best technique for applying edible coatings for industrial purposes compared to other methods.
• Solvent Casting: This is another method used in the food industry for applying coatings.
• Other strategies mentioned include brushing, individual wrapping, spreading, and fluidized-bed handling.

The choice of application method depends on the type of food product, the desired thickness and uniformity of the coating, and the scale of production. Regardless of the method, the applied ECF should be consistent and free of faults. Achieving suitable adhesion properties during the implementation of ECFs can be challenging. Furthermore, it is important to note that edible films can also be produced separately using methods like film casting in the lab and then potentially used to wrap food items, though the primary focus of the sources is on coatings applied directly in liquid form.

The ongoing exploration of novel materials and advancements in formulation techniques are expected to shape the future of edible films and coatings. Research efforts are likely to focus on improving mechanical qualities, barrier capabilities, and stability to broaden their applicability across diverse food applications. Furthermore, the development of ECFs with enhanced antibacterial properties and the application of nanotechnology in their production represent promising areas for future study.

The edible films and coatings are not merely a trend but a significant evolution in food packaging technology. Their capacity to preserve food quality, extend shelf life, reduce environmental impact, and potentially enhance nutritional value positions them as a crucial element in creating more sustainable and efficient food systems for the future. Continued innovation and wider adoption of ECFs hold the key to addressing global financial issues and environmental concerns associated with food production and consumption.

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TZ Test: Quick method to determine seed viability

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ARTICLE ID: 16

Introduction:

A seed is considered viable when it is live and potentially capable of germination. Viability denoted the degree to which a seed is alive, metabolically active and possesses enzymes capable of catalyzing metabolic reactions needed for germination and seedling growth.

NEED FOR FAST VIABILITY TESTS:

- ✓ To determine the viability of seed lots within a short time to make fast decisions in supply and marketing of the seeds.
- ✓ When speed is important and quick decisions about the viability levels of a seed lot has to be made on a short notice, whether the seeds are dormant or non-dormant.
- ✓ This is particularly useful for freshly harvested seeds that possess high levels of dormancy such as some grasses and native species. While germination test takes 3-4 weeks to be completed in most grass species, a TZ test can be finished within 24-48 hours.
- ✓ It can be used as a vigor test by classifying the seeds into high, medium, low and non viable seeds based on the staining pattern of the seeds.

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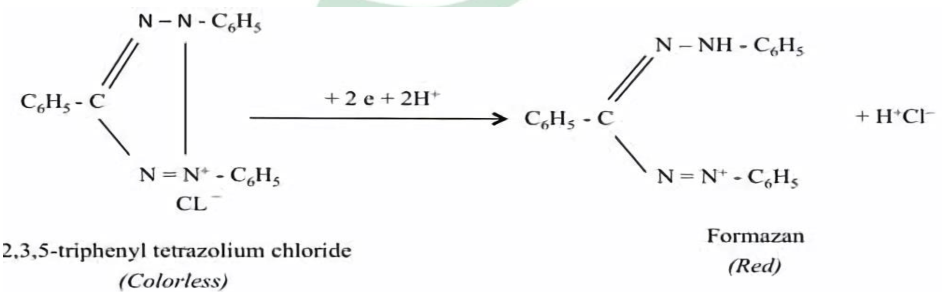
Tetrazolium Test:

This test was developed during early 1940's by Professor George Lakon of Germany. This test is widely recognized as easy, accurate and popular method of testing seed viability. Also referred as quick test since it can be completed in only a few hours. The test is very useful in processing, handling, storing and marketing large quantities of seed in a short time, testing dormant seed lots and vigour rating of the seed lots.

Principle of the test: The TZ is a biochemical test, which differentiates live from dead seeds based on the activity of the respiration enzymes in seeds. All living tissues, which respire, are capable of reducing a colourless chemical 2,3,5 triphenyl tetrazolium chloride or bromide into a red coloured compound 'Formazon' by H transfer reactions catalysed by the enzyme debydrogenases. This makes it possible to distinguish the red –coloured living parts of seeds from the colourless dead ones. The viability of seeds is interpreted according to the staining pattern of seed tissues.

Mechanism of the Reaction:

Since the tissues within a seed could be at different states of viability they would be stained differently. Moore (1973) described the use of TZ staining more efficiently on the basis of the topographic pattern of the seed. The chemical reaction that changes the colourless tetrazolium solution into formazon:



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Reagents:

Tetrazlium solution: A solution of 2, 3, 5-triphrnyl tetrazolium chloride or bromide of pH 6.6-7.5 is used. Concentration normally used should be 1.0%. However, lower or higher percentages are permissible. Distilled/deionized water should be used in the preparation, and the TZ solution should have a pH of between 6.5 and 7.5. To ensure the ph within the required range, a phosphate buffer should be used.

Procedure:

Seeds are first imbibed on a wet substratum to allow complete hydration of all tissues. For many species this solution can be added to the intact seed. Other seeds must be prepared by cutting and puncturing in various ways to permit access of the tetrazolium solution to all parts of the seeds. After hydration seeds are soaked in TZ salt solution for complete coloration.

A. Working samples: A test must be carried out on four replicated of 100 pure seeds drawn randomly from the pure seed fraction of the sample.
B. Preparation and treatment of the seed: The seed must be prepared in order to facilitate penetration of the TZ solution.

1. Premoistening the seed: It is necessary preliminary step to staining for some species and a highly recommended one for others. Imbibed seeds are generally less fragile than dry seeds and can be cut or punctured more rapidly. If the seed coat hampers imbibitions, the coat must be punctured.
   i) Slow moistening: Seed is allowed to imbibe on top of the paper or between the paper according to the method used for germination testing. The technique should be used for those species that are inclined to fracture if immersed directly in water. (e.g) Large seeded legumes Seeds of soybeans and other large seeded legumes may swell so rapidly

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and irregularly when placed directly in water or TZ solution that the seed coats burst.

Hence, it is preferable to condition these seeds slowly in moist paper towels overnight before staining, so that they absorb moisture slowly without any damage to the seed. While in some species, slow moistening will not result in full imbibitions and a further period of soaking in water will be necessary.

ii) Soaking in water: Seeds should be fully immersed in water and left until completely imbibed. If the soaking period is more than 24 h, the water should be changed.

Standard procedures for TZ testing:

ecies	treatment type/minimum time (h)	paration before staining	ining solution %	timum staining time (h)	paration for evaluation	mitted non-viable tissue
ıssica spp.	18	ise seed coat crosswise at one of the outer cotyledons, avoid damaging hypocotyls or radical, remove seed coat by gently pressing			serve embryo	radicle, measured from radical tip, 1/3 superficial necrosis on the cotyledons not in connection with the hypocotyls
yza sativa	18	longitudinally through embryo and ¾ of endosperm			serve cut surface	radicle
ghum spp.	at 7°C/18	longitudinally through embryo and ¼ of endosperm			serve cut surface	radicle measured from radical tip
ticum spp	18	longitudinally through embryo and ¾ of endosperm			serve external embryo surface, cut surface, back of scutellum	ot area except one root initial, ½ of extremities of scutellum
ı mays	18	longitudinally through embryo and ¾ of endosperm			serve cut surfaces	marty root, 1/3 extremities of scutellum

Premoistening at 20°C in water (w), between paper (BP), Sand (S)

2. Exposure of tissues prior to staining: It is necessary to expose the tissues prior to staining to allow easier penetration of the TZ solution and to facilitate evaluation. Tissues that must be critically examined to establish the viability of a seed are considered to be essential tissues while those that are less essential for this diagnosis are non-essential.

   i) Piercing the seed: Premoistened or hard seeds should be pierced at a non-essential part of the seed using a needle or sharp scalpel.

   ii) Longitudinal cutting:

   —For all cereals and grasses seeds: Through middle of the embryonic axis and three quarters of the length of the endosperm

   —For dicot seeds without endosperm and with a straight embryo a cut should be made through the middle of the distal half of the cotyledons, leaving the embryo axis uncut

   —In seeds where there is an embryo surrounded by living tissue, a longitudinal cut can be safely made along the embryo

   iii) Transverse cutting: Cutting is made through non-essential tissues using scalpels, razor blades, etc

   iv) Transverse incision: May be used as a substitute for a transverse cut and is the preferred method for small grass seeds

   v) Excision of the embryo: The embryo is excised with a dissecting lancet. Ex. Hordeum, Secale and Triticum

   vi) Removal of the seed coat: In some species the whole seed coat and any other covering tissues must be removed. (e.g) Dicots with seed coats impermeable to tetrazolium.

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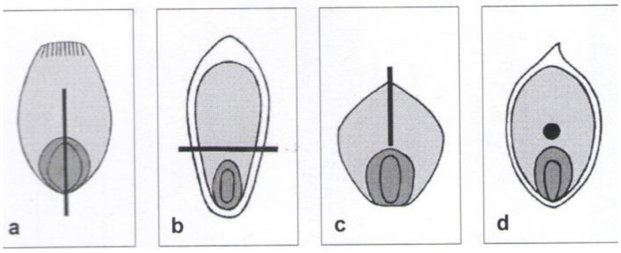

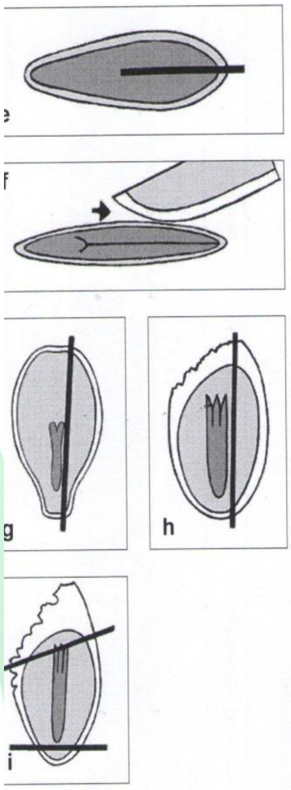

Fig: Preparation procedure
The figures show the position of different cuts for preparation before stating.

a. Longitudinal bisection through embryo and approximately ¾ of the endosperm of cereals and grass seeds.
b. Transverse cut
c. Longitudinal cut through distal part of the endosperm
d. Piercing through endosperm
e. Longitudinal cut through distal half of cotyledons
f. Longitudinal section showing the position of the scalpel when making a cut
g. Longitudinal cut alongside the embryo (species with straight embryo)
h. Longitudinal cut alongside the embryo of coniferous seeds
i. Transverse cut at both ends to open embryo cavity by removing fractions of endosperm.

C. Staining: The prepared seeds or embryos should be completely immersed in TZ solution. Small seeds, which are difficult to handle, may be premoistened and prepared on a strip of paper, which is then folded or rolled up and immersed in TZ solution. Staining temp must be in the range of 20-40^{o}C. The staining time varies for different kinds of seeds, different kinds of seeds, different methods of preparation, and different temperatures (< 1 hr to 8 hrs). At the end of the staining period the solution is decanted and the seed rinsed with water and examined.

D. Evaluation: A normal TZ stain appears cherry red.

✓ The main purpose of the TZ test is to distinguish viable and non-viable seeds. Each seed is examined and evaluated as viable or non-viable on the basis of the staining patterns and tissues soundness revealed. A viable seed should show staining in all those tissues whose viability is necessary for normal seedling development.

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- ✓ The TZ test is often called the topographical TZ test because the pattern or topography of staining is an important aspect of its interpretation. Staining pattern reveals the live and dead areas of the embryo and enables the analyst to determine if seeds have the capacity to produce normal seedlings.
- ✓ Whether a seed is rated viable or non-viable is derived directly from the importance of the different seed tissues responsible for the emergence and development of a normal seedling.
- ✓ Most seeds contain essential and non-essential tissues. Essential structures are the meristems and all structures as necessary for the development of normal seedlings.
- ✓ Viable seeds are those that that show the potential to produce normal seedlings. Such seeds stain completely, or if only partly stained, the staining patterns indicate that the essential structures are viable.
- ✓ Hard seeds are seeds with water–impermeable seed coat and remain hard even after premoistening.
- ✓ A viable seed should show by its biochemical activity the potential to produce a normal seedling. A non-viable seed shows deficiencies or abnormalities of such a nature as to prevent its development into a normal seedling.
- ✓ In addition to completely stained viable seeds and completely unstained non-viable seeds, partially stained seeds may occur.
- ✓ Varying proportions of necrotic tissue are found in different zones of these partially stained seeds.
- ✓ The position and size of the necrotic area, and not necessarily the intensity of the colour, determine whether such seeds are classified as viable or non-viable.

The seeds are evaluated with the help of magnifying devices. Individual seed is evaluated as viable or dead on the basis of staining pattern in embryo followed by cotyledons.

A) Assessment on the basis of staining of embryo:

- ✓ Embryo completely stained-viable
- ✓ Embryo unstained –non viable
- ✓ Plumule or radical unstained non viable

B) Assessment on the basis of cotyledon:
- ✓ Complete staining-viable
- ✓ No staining- non viable
- ✓ Necrosis- evaluation on the basis of category

C) Assessment on the basis of necrosis:
- ✓ Unstained tissues at the attachment of the embryo-non viable
- ✓ Unstained tissues are away and ara not connected with embryo-viable

D) Assessment on the basis of colour intensity
- ✓ Dark red- vigorous seed
- ✓ Pink colour-weak seed
- ✓ Dark red fractured – non viable

Calculations: The results are reported as percentage of viable seeds in relation to total seeds tested.

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Reviving Tradition: Liquid Organic Manures for Eco-Friendly Disease Management in ZBNF

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Abstract

The overuse of chemical pesticides has raised significant concerns about environmental health, soil degradation, and food safety. In response, Zero Budget Natural Farming (ZBNF), championed by Subhash Palekar, emphasizes the use of traditional liquid organic manures such as Jeevamrit, Beejamrit, Panchagavya, Sonthastra, Khatti Lassi, and Brahmastra. These formulations, derived from cow-based products and medicinal plant extracts, are rich in beneficial microbes and secondary metabolites with proven antimicrobial properties. This review outlines their preparation, microbial composition, and effectiveness in managing key plant pathogens such as *Fusarium spp.*, *Rhizoctonia solani*, *Colletotrichum spp.*, and root-knot nematodes. These bio-inputs enhance soil fertility, improve crop resilience, and provide a sustainable alternative to synthetic agrochemicals, aligning traditional practices with modern ecological farming needs.

Keywords:

Zero Budget Natural Farming, liquid organic manure, Jeevamrit, Beejamrit, Panchagavya, Brahmastra, plant disease management, sustainable agriculture, biocontrol, soil microbiome

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Introduction

As concerns over chemical pesticide overuse grow impacting not only soil health and beneficial microbes but also food safety and the environment many farmers are turning to traditional, eco- friendly alternatives. Liquid organic manures such as Jeevamrit, Beejamrit, Panchagavya, Sonthastra, Khatti Lassi, and Brahmastra are emerging as powerful tools in plant disease management, particularly under the Zero Budget Natural Farming (ZBNF) model popularized by Subhash Palekar (Palekar, 2006). These formulations, made using natural ingredients like cow dung, cow urine, medicinal plants, and fermented dairy products, are rich in beneficial microorganisms and bioactive compounds. They have shown effectiveness in suppressing plant pathogens and promoting healthy crop growth. For example, Jeevamrit contains bacteria such as *Azospirillum*, *Pseudomonas*, and phosphate-solubilizing microbes, which enhance soil fertility and suppress pathogens like *Alternaria alternata* and *Fusarium graminearum* (Sreenivasa *et al*., 2009; Sharma *et al*., 2024). Similarly, Beejamrit aids in seed treatment and has been shown to reduce infections from *Cercospora* and *Colletotrichum* species (Mukherjee *et al*., 2009; Pawar *et al*., 2024). Panchagavya, another age-old preparation, has demonstrated strong antifungal potential against soil-borne pathogens such as *Fusarium oxysporum*, *Rhizoctonia solani*, and *Sclerotinia sclerotiorum* (Basak & Lee, 2005; Sumangala & Patil, 2009). In addition, Sonthastra and Khatti Lassi—made from ginger and sour buttermilk respectively—are valued for their natural antifungal and antibacterial properties, aiding in the control of leaf blights and rust diseases (Kumar *et al*., 2020; Tak *et al*., 2021). Perhaps the most potent among these is Brahmastra, aptly named after the mythological weapon, which combines medicinal plant extracts with cow urine. Its application has led to reduced incidence of foliar fungal diseases and even nematode infestations in crops like rice and tomato (Devapatni *et al*., 2023; Maru *et al*., 2021). Together, these bio-inputs represent a sustainable and regenerative approach to agriculture, offering a cost-effective, environmentally sound, and culturally rooted method of managing plant health.

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Jeevamrit

Jeevamrut, formulated using cow-derived products, are rich in beneficial microorganisms such as *Azospirillum*, *Azotobacter*, phosphobacteria, *Pseudomonas*, lactic acid bacteria, and methylotrophs. Additionally, they harbor beneficial fungi and actinomycetes, which contribute to soil health and plant growth (Sreenivasa *et al*., 2009). Bacterial phyla such as *Bacillus*, *Pseudomonas*, *Rhizobium*, and *Paenibacillus* were predominantly present. In contrast, *Ascomycota* was the dominant fungal phylum found in the soil sample (Saharan *et al*., 2023)

Take 10 kg of fresh cow dung and 10 litres of cow urine

↓

Add 1 kg of jaggery and 1 kg of gram flour

↓

Add 200 grams of soil from the root zone of a healthy plant

↓

Mix all ingredients in 200 litres of water in a barrel

↓

Stir thoroughly, twice daily (morning and evening), for 5 to 7 days

↓

Jeevamrit is ready for us

Beejamrit

It is a traditional organic preparation where *Beej* means seed and *Amrit* signifies a nourishing or life-giving liquid. It is a natural input primarily composed of cow dung and cow urine. To enhance its effectiveness, it is typically enriched overnight with soil from undisturbed forest areas, and occasionally, limestone is also added (Sreenivasa *et al*., 2009). Beejamrit contains plant-beneficial bacteria, and such as free-living nitrogen fixers and phosphate solubilizers—gradually increase, reaching their peak by the fourth day of incubation. Likewise, indolic compounds, including indole acetic acid, accumulate to their highest levels in Beejamrit after four days of decomposition (Mukherjee *et al*., 2009).

Take 5 kg of freshly collected cow dung

↓

Pour in 5 litres of cow urine

↓

Prepare a lime solution by dissolving 50 grams of lime (chuna) in water, then add it to the mix

↓

Optionally, include a small amount of soil taken from the root zone of a healthy plant or fertile field

↓

Stir the mixture thoroughly until it becomes a uniform blend

↓

Beejamrit is now ready to be used for seed treatment

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Panchagavya

In Sanskrit texts, *Panchagavya* refers to a mixture composed of five cow-derived products. Each individual component is known as *Gavya*, and collectively, they are referred to as *Panchagavya*. It is applied in various ways, including as a foliar spray, through soil incorporation with irrigation, and for treating seeds before planting. The use of Panchagavya promotes the development of lateral shoots in plants, which contributes to enhanced fruit production. This natural formulation is also significantly boosting root growth in plants (Kumar *et al*., 2020).

Thoroughly mix fresh cow dung with cow ghee
↓
Let the mixture ferment for 2 days
↓
Add cow urine along with 5 liters of water
↓
Stir the mixture well twice daily (morning and evening) for one week
↓
Incorporate 500 grams of gram flour
↓
Add cow milk and curd to the mixture
↓
Continue stirring twice daily for an additional two weeks
↓
The Panchagavya preparation is now complete and ready for use

Sonthastra

Sonthastra is a natural remedy used in Zero Budget Natural Farming (ZBNF) to help manage fungal issues in crops. It is made using simple, naturally available ingredients like dry ginger (*Zingiber officinale*) and indigenous cow's milk, both known for their antimicrobial qualities. To prepare it, dry ginger is ground into a powder, boiled in water to extract its beneficial compounds, and then mixed with previously boiled and cooled cow's milk. (Kumar *et al*., 2020). This blend is further diluted in water and sprayed on plants as a foliar application. Sonthastra offers an eco- friendly and chemical-free alternative for farmers aiming to control fungal diseases sustainably (IJSR 2014).

Grind 200 grams of dry ginger into a fine powder
↓
Mix the ginger powder with 2 liters of water and bring it to a boil
↓
Boil until only 1 liter of ginger decoction remains, then let it cool
↓
In a separate pot, boil 5 liters of desi (indigenous) cow's milk once
↓
Cool the milk and remove the cream for household use
↓
Strain both the ginger extract and the milk using a clean cloth
↓
Combine the filtered ginger water and boiled milk into 200 liters of clean water
↓
Stir thoroughly and spray over one acre of crop area.

Khatti lassi (sour buttermilk)

Khatti lassi (sour buttermilk) is an effective bio-input in Zero Budget Natural Farming (ZBNF), widely used for managing crop diseases. Rich in lactic acid bacteria (LAB), it naturally suppresses harmful pathogens by producing organic acids and antimicrobial compounds. When applied to soil or foliage, it improves microbial balance, reduces fungal infections, and supports plant immunity—making it a sustainable and eco-friendly alternative to chemical treatments (Gajbhiye *et al*., 2018).

Take 5 liters of 3–5-day-old sour buttermilk (*khatti lassi*)
↓
Place a small piece of copper into the lassi and let it soak for 3–5 days
↓
After soaking, remove the copper and mix the lassi into 100 liters of clean water
↓
Dissolve 50 grams of turmeric powder into the mixture
↓
Stir thoroughly to ensure even distribution
↓
Spray the solution on crops to help manage plant health naturally

Brahamastra

The name of this pesticide is derived from Sanskrit, combining 'Brahma', which signifies divine or supreme, with 'astra', meaning weapon. According to Indian mythology, the Brahmastra was a powerful weapon used to combat evil forces (Devapatni *et al*., 2023). Due to the presence of phytochemicals like azadirachtin from neem and other secondary metabolites, Brahmastra exhibits antibacterial and antifungal effects. It repels a variety of insect pests, reducing the chances of vector-borne diseases. Its regular application has been associated with a reduction in the incidence of foliar diseases, fungal infections, and insect-transmitted pathogens, especially in vegetable and cereal crops. (Palekar,2006).

Take 10 liters of cow urine
↓
Add 3 kg of neem (*Azadirachta indica*) leaf paste
↓
Add 2 kg of karanj (*Millettia pinnata*) leaf paste
↓
Add 2 kg of dhatura (*Datura* sp.) leaf paste
↓
Add 2 kg of custard apple (*Annona reticulata*) leaf paste
↓
Mix all ingredients thoroughly
↓
Boil the mixture on a medium flame 4–5 times
↓
Allow it to cool and rest for 24 hours
↓
Stir the solution clockwise for 2–3 minutes in the morning and evening
↓
Ferment the mixture for 48 hours
↓
Filter the solution
↓
Now the Brahmastra is ready to use

Name of liquid organic manure	*Controlled plant pathogen*	*Reference*
Jeevamrut	*Alternaria alternata, Puccinia graminis f. sp. Tritici, Colletotrichum lindemuthianum, Bipolaris sorokiniana, colletotrichum truncatum, Ginger rhizome rot, Fusarium graminearum*	Pandia *et al*. (2019), Sharma *et al*. (2024), Sharma *et al* (2021), Dibya *et al.* (2020), Chatak, S. (2020), Ajaykumara *et al*. (2023), Kaur and Rana, (2022).
Beejamrut	Cercospora leaf spot in okra, *colletotrichum truncatum, Fusarium graminearum,* Paddy blast, *Sclerotinia sclerotiorum*	Pawar *et al* (2024), Chatak, S. (2020), Kaur, G. and Rana, S. K. (2022), Rana *et al*. (2016)
Panchagavya	The antifungal potential of Panchagavya was evaluated against many soil-borne pathogens, including *Fusarium solani* f. sp. *pisi*, *Fusarium oxysporum* f. sp. *pisi*, *Rhizoctonia solani*, *Sclerotium rolfsii*, and *Sclerotinia sclerotiorum, Curvularia lunata*	Basak and Lee (2005), Sumangala and Patil (2009).
Sonthastra	Controlling fungal disease	Kumar *et al* (2020).
Sour Butter Milk	Alternaria leaf blight, Yellow rust of wheat, Yellow Sigatoka disease of banana	Hongal *et al* (2023), Tak *et al* (2021), Nagesh *et al* (2023)
Brahamastra	Brown spot of rice, Root knot nematode in tomato,	Srinivasarao *et al* (2015), Maru *et al* (2021)

Conclusion

The increasing awareness of the adverse effects of chemical pesticides has inspired a shift toward more sustainable, eco-friendly agricultural practices. Liquid organic manures such as Jeevamrit, Beejamrit, Panchagavya, Sonthastra, Khatti Lassi, and Brahmastra have emerged as practical, cost-effective, and environmentally safe alternatives under the Zero Budget Natural Farming (ZBNF) paradigm. Each formulation harnesses the power of natural ingredients and beneficial microorganisms to promote plant health and combat a wide spectrum of plant pathogens—including *Fusarium*, *Colletotrichum*, *Alternaria*, and even nematodes—without disturbing ecological balance (Palekar, 2006; Basak and Lee, 2005; Sharma *et al*., 2024;