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# Health Benefits of Black Soybean

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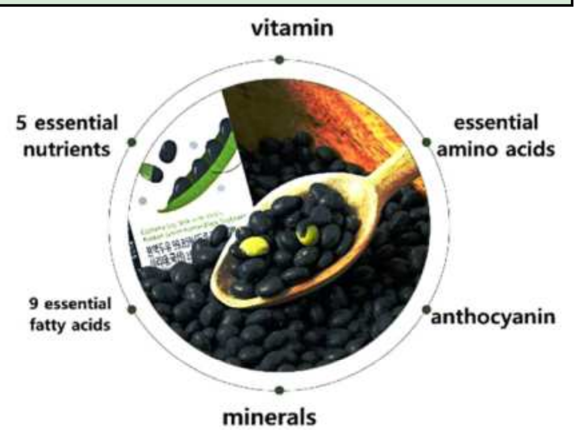
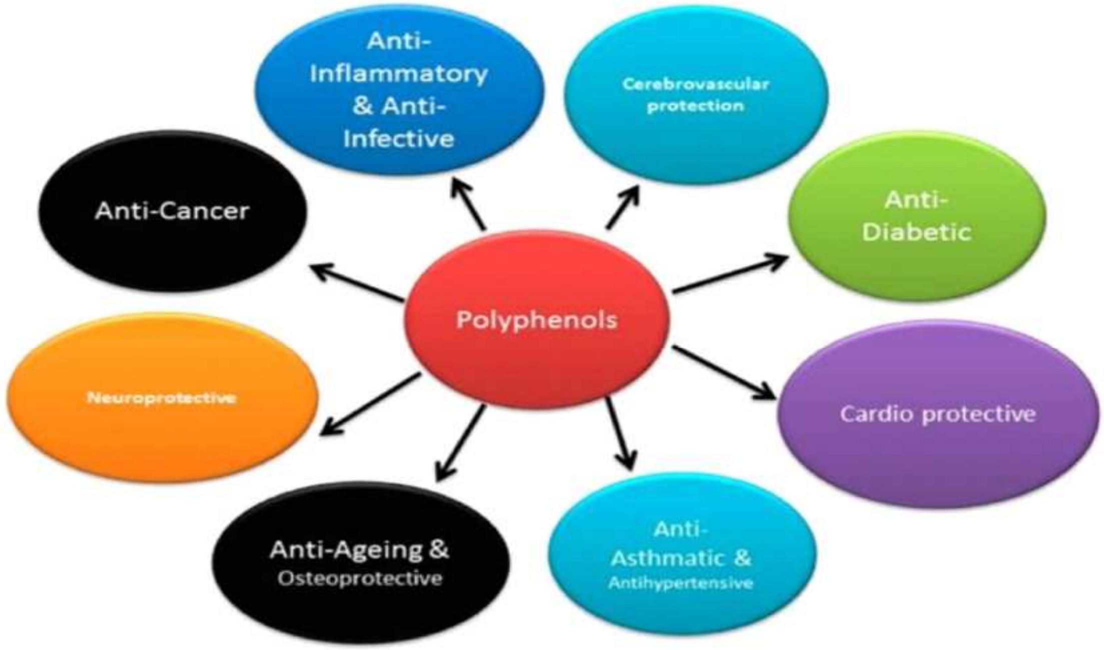
## Introduction

Black soybeans (*Glycine max* (L.) Merr.), known by local names such as Bhatt, Bhatmash and Kala Bhatt are soybeans with a black seed coat. It is believed that it was introduced through Myanmar by Indonesian traders. In India, it has been traditionally grown on a small scale in states like Himachal Pradesh, East Bengal, Kumaon and Garhwal hills of Uttarakhand, small parts of Central India and Khasi hills. In Uttarakhand it is mainly cultivated as a food crop in the Kumaon and Garhwal region and frontiers of Uttarakhand state at an area of 5734 ha, with a production of 5636 tonnes and productivity of 9.82 q/h.

The green and dried vegetative components of the black soybean are utilized as fodder, while the seeds are primarily consumed as a pulse by the people. In comparison to other pulses, the black soybean has a higher protein level (32-48.46 %) and calcium content (387 mg/100 g). It also contains a superior level of unsaturated fatty acids, with a fat content of 15.5-24.7 percent.




Because of the presence of higher phenolic content in the seed coat and rich is isoflavones, the antioxidant properties of black soybean are greater than the yellow variety. Anthocyanins are abundant in black soybean, Major anthocyanins, such as cyanidin-3-glucoside, delphinidin-3-glucoside and pelargonidin-3-glucoside, have been extracted and identified from the seed




coat of black soybean. The anthocyanins found in black soybeans have a variety of health benefits, including improving bone stability, lowering blood pressure, reducing cardiovascular problems, preventing cancer, lowering body weight and having antibacterial properties. Being a rich source of isoflavones in the human diet, its consumption has been considered benefic-ial, with a potentially preventive effect against several chronic disorders. It also contains high tocopherol (vitamin E), flavonoids and anthocyanin which possess biological activity. Comparatively higher antioxidant activity, free radical scavenging effect and total phenolics are found in black soybean than the yellow soybean. It has been widely consumed or widely utilized as health promoting food in China, India, Japan and Korea due to its excellent nutritional and remedial properties. Here are some Health benefits of black soybean.

**Prevent major diseases in human beings**

Black soybean contains high concentration of bioactive components such as polyph-enols, flavanols, lignans, phytoestro-gens and polysaccha-rides and its consumption is associated with variety of black soybean contains a range of phytochemicals and to be potentially useful in avoiding cancer, diabetes, cardiovascular disease, cerebr-ovascular illness and neurological diseases.

**Enhance bone stability**

Black soybean is high in proteins and fibres and a large number of minerals like calcium, phosphorus, magnesium, iron, manganese, copper, zinc and these are necessary for maintaining bone stability and strength. It contains isoflavone which is genistein and it has been indicated to minimise bone density and boost bone mineral in osteoporosis.

**Reduce Blood Pressure**

Black soybeans have a low salt content, which can help to maintain the blood pressure. anthocyanins found in black soybean reduce the risk of cardiovascular disease and maintain blood pressure in those who are affected. Furthermore, black soybean has been shown to have substantial inhibitory activity on collagen induced platelet aggregation, as well as the potential to lower cardiovascular risk and improve the blood circulation. Black soybeans are also high in fibre, potassium, folic acid, pyridoxal phosphate and phyto-nutrients (quercetin and saponins), which helps to prevent cardiovascular issues. The high fibre content of black soybeans aids in the reduction of total and LDL cholesterol levels in the body, minimising the risk of heart disease. Black soybean has been demonstrated to decrease oxidative stress in postmenopausal women due to its high antioxidant activity and improved lipid profiles.

### Reduce Cardiovascular Complications

The consumption of black soybean has been linked to a lower risk of cardiovascular disease that to decrease the effect of low density lipoprotein oxidation, as well as TNF-alpha-induced vascular cell adhesion molecule-1 (VCAM), intracellular adhesion molecule-1 (ICAM) and cyclooxygenase-2 levels, in their studies. The seed coat of black soybean contain higher amount of anthocynin and which is helpful in lowering the pathological illnesses.

### In Managing Diabetes

Seed coat of black soybean help to reduce obesity because it contains high amount of fiber and it helps to lower blood sugar level. One cup of black soybean has roughly contains 15 g of fiber. High amount of fiber in diet which increase energy consumption and decrease inflammation. The polyphen-ol-rich dietary material identified in the black soybean seed coat extract which includes 9.2% cyanidin 3-glucoside, 6.2% catechins, 39.8% procyanidins and others.

### Cancer prevention

Several researches have shown that anthocyanin-rich black soybean suppresses oxidative stress and inflammatory reactions, which inhibits cancer cell proliferation. Additionally, soybean contains saponins and folic acid which prevent cancer cells from reproducing and spreading throughout the body, folic acid is essential for DNA synthesis and repair.

### Reduce Body Weight

Many studies have suggested that eating anthocyanin-rich black soybean reduces the risk of adipogenic activity and obesity. While encourage a healthy complexion, visceral fat, increased energy and overall reduce the body weight.

### Antimicrobial Actions

Antibacterial, antifungal, and antiviral activities have been existing in black soybean. The extract from black soybean had a substantial effect on the growth of food-borne pathogens such as E. coli, *Salmonella typhimurium* and *Campylobacte jejuni* in broth-cultures as well as on chicken skin. An isolated monomeric protein with an N-terminal sequence that mimics a chitin synthase region and the protein, had antifungal and antiviral properties against *Fusarium oxysporum and Mycosphaerella arachidicola*.

### Conclusion

In several Health Benefits and The richness of various nutritional and remedial bioactive compounds, makes black soybean is a wholesome food, to be added to daily meals as supplement to cereal based diet.

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# Technology Development in Wastewater Management for Agriculture

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## Introduction

India, second largest populous country in the world with 1.38 billion people in which 65% (900 million) live in rural areas and 35% (483 million) are concentrated in urban centres. The wastewater generation is estimated approximately 39,604 Million Litres per Day (MLD) in the rural regions and 72,368 MLD in the urban centres for the year 2020-21 (NITI Ayog, 2022). The estimated volume of urban wastewater is almost twice (due to the associated water needs for flushing and sewage drainage) that of rural and such availability of more water for sanitation has increased the living standards in urban cities. It was estimated that 380 billion m3 of wastewater is generated annually across the world. Based on the population growth and urbanization, the daily wastewater generated is expected to increase by 24% (470 billion m3) by the end of the SDG era in 2030 and 51% (574 billion m3) by 2050 over the current estimates. Asia generated the largest volumes of wastewater representing 42% (159 billion m3) of the wastewater globally and it is expected that it will increase upto 44% by 2030 (Qadir *et al*., 2020).

### Wastewater

Wastewater typically consists of a mixture of various sources that contribute to its pollution. This includes domestic effluent, which is divided into black water-comprising urine, excreta and toilet wastewater and grey water, which comes from kitchens and bathing. Additionally, wastewater can include water from commercial establishments and institutions, such as hospitals, as well as industrial effluents and stormwater, along with other urban runoff. This combination of sources makes wastewater a complex and often contaminated form of water.

**Difference between conventional and non-conventional wastewater treatment methods**

| Conventional wastewater treatment methods | Non-Conventional wastewater treatment methods |
|---|---|
| • Requirement of high energy<br>• High skilled manpower is required<br>• Costly methods<br>• Generation of hazardous sludge<br>• Unsustainable<br>**Methods:** Activated sludge, trickling filter, rotating biological contactor methods | • Low-cost<br>• Low-technology<br>• less sophisticated in operation<br>• More effective in removing pathogens<br><br>**Methods:** Stabilization ponds, constructed wetlands, oxidation ditch, soil aquifer treatment |

**Major crops irrigated with wastewater**

- **Cereals:** In a 10 km stretch of the Musi River in Hyderabad, Andhra Pradesh and wastewater from the city is used to irrigate 2,100 hectares of land for paddy cultivation. Similarly, wastewater is utilized for irrigating wheat crops in Ahmedabad and Kanpur.
- **Vegetables:** In New Delhi, around 1,700 hectares of land near the Keshopur and Okhla sewage treatment plants (STPs) are utilized to grow various vegetables irrigated with wastewater. Summer crops include cucumbers, eggplant, okra and coriander, while spinach, mustard, cauliflower and cabbage are grown in the winter.
- **Flowers:** In Kanpur, farmers use wastewater to grow roses and marigolds, while in Hyderabad, they cultivate jasmine using wastewater irrigation.
- **Avenue trees and parks:** In Hyderabad, secondary treated wastewater is used to irrigate public parks and avenue trees.
- **Fodder crops:** In Hyderabad, along the Musi River about 10,000 ha of land is irrigated with wastewater to cultivate paragrass, a kind of fodder grass.
- **Aquaculture:** The East Kolkata sewage fisheries are the largest single wastewater use system in aquaculture in the world.
- **Agroforestry:** In the villages surrounding Hubli-Dharwad in Karnataka, wastewater is used to irrigate a variety of plantation trees including sapota, guava, coconut, mango, arecanut, teak, neem, banana, ramphal, curry leaf, pomegranate, lemon, galimara and mulberry.

Using untreated wastewater for agricultural irrigation offers several advantages, including cost-effective and reliable irrigation, increased urban agricultural production, enhanced food security and improved livelihoods for urban farmers, though it can negatively impact farmer's health. However, it also poses significant disadvantages, such as soil salinization, metal toxicity, structural degradation, reduced aeration and pore clogging, as well as potential heavy metal accumulation in crops, microbial contamination and nitrate leaching into groundwater. On the other hand, treated wastewater presents benefits like the need for knowledge regarding the wastewater-soil-plant system, cooperation between wastewater treatment plant operators and farmers and adherence to specific soil and crop restrictions. While it leads to higher crop yields, year-round production and the ability to expand the range of irrigated crops, it also recycles organic matter and nutrients back into the soil, thereby reducing reliance on synthetic fertilizers.

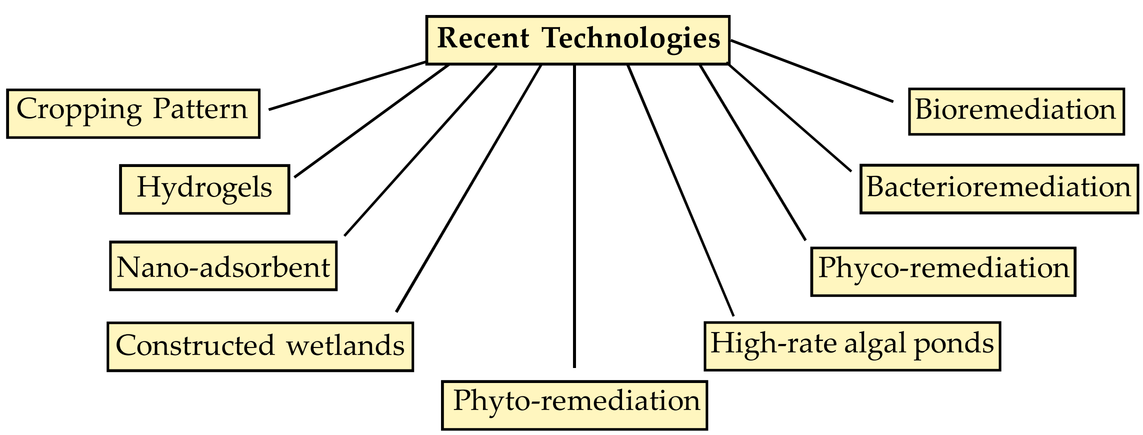


**Fig. 1. Recent Technologies in Wastewater Management**

**Bioremediation**

It is the process of using microorganisms, green plants or their enzymes to eliminate undesirable pollutants and their effects from the environment. Wastewater bioremediation is a specialized application of bioremediation where micro-organisms, plants or enzymes are used to treat contaminated water, especially wastewater from industrial, agricultural or domestic sources. This process helps remove or degrade pollutants, including organic matter, heavy metals and harmful chemicals, there by purifying the water and making it safer for discharge into the environment or for reuse.

**Bacterioremediation**

It has the ability to flourish in wastewater bodies due to its adaptive traits and metabolic flexibility, which allow it to remove high quantities of nitrogen and phosphorus. It removes heavy metals from polluted soils, including Cd, Cr, Cu, cobalt (Co), Ni, Pb and Zn, by absorbing metal ions. Example: *Synechocystis* spp. mineralized the herbicide anilofos and used the product as a phosphate source.

**Phyco-remediation**

Phyco-remediation uses algae to detoxify water bodies. Algae can change the quality of wastewater by adjusting numerous biochemical factors. Plants are inexpensive and simple to manage due to their autotrophic nature. They are environmentally beneficial, reducing the environmental impact of toxicants while stabilizing pollutants to prevent spread. Vegetation also helps to minimize soil erosion and increases soil fertility by releasing organic compounds. These advantages make plants a viable option for large-scale environmental rehabilitation.

**High-rate algal ponds**

High-rate algal ponds (HRAP) are shallow, paddlewheel-mixed, open raceway ponds that use algae species to treat wastewater. They rely on a symbiotic relationship between bacteria and microalgae, where algae produce oxygen through photosynthesis for bacterial decomposition of organic matter, while bacteria provide nutrients for algal growth. The resulting algal biomass can be used for biofuel production. When comparing HRAP to waste stabilization ponds (WSP), HRAP can achieve the same level of nutrient and pathogen removal as WSP but requires only 40% of the land area. (El Hamouri *et. al.,* 2003). It is most cost-effective solution than WSP. The continual mixing of HRAP promotes algae growth, improves pathogen die-off and nutrient removal and produces more consistent treated water than WSP.

**Phyto-remediation**

Phytoremediation involves using plants to extract, sequester or detoxify environmental pollutants. This approach effectively eliminates contaminants from soil, sludge, groundwater, surface water and sediments (Segura and Ramos, 2013). Plants used in phytoremediation must be carefully harvested, processed and disposed of to prevent further environmental damage. Common species include mustard, hemp, water hyacinth, alpine pennycress and pigweed, which effectively absorb pollutants. This cost-effective, eco-friendly method prevents contaminant spread, improves soil fertility, and offers a sustainable solution for managing environmental pollution.

**Constructed wetlands**

Constructed wetlands (CW), also known as reed beds, artificial wetlands, planted soil filters or vegetated submerged beds, were the first nature-based solution adapted for wastewater treatment. CWs are artificially created systems that are planned and built to use natural processes to remove contaminants from polluted water in a more controlled environment. This system is made up of water, plants, growing media, soil and microbes, which use complicated mechanisms to treat wastewater. Wetland plants are herbaceous, fast-growing species with large biomass and great absorption abilities. Based on the water flow characteristics, CWs are categorised as free water surface (FWS) and subsurface flow (SSF). In an FWS, water gently flows above the substrate media, providing a free water surface and a few centimetres of water column depth. On the other hand, water flows inside a porous substrate in SSF systems. SSFs are further classified into horizontal and vertical flow systems based on the flow direction.

**Nanoparticles for treatment of wastewater**

Deals with manufacturing or manipulation of materials at nanoscale (10-9m). It has large surface area, excellent stability, compressibility with negligible reduction in surface area and remarkable recyclability and reusability. The Nano-filters used in agriculture are made of carbon nanotubes. It has greater efficiency than micro-filters and ultrafilters. The Nanofilms, nanocatalysts and nano adsorbents are used for the removal of organic contaminants. It is aslocused in desalination operations. It has applications in many different fields, like electronics, medical, energy sector, environmental remediation. It is being evaluated in water treatment processes in recent years. Materials having nanoscale dimensions referred to as Nanomaterials.

**Plant based Nano particles**

- **Fe-mediated nanoparticles:** from eucalyptus leaves and green tea have high nitrate removal efficiency (Wang *et. al.*, 2014)
- **Nano-adsorbent:** *Serratia* sp. And *Hydroxyapatite crystallite* treat wastewater polluted with phosphates

**Hydrogels or Superabsorbent polymers (SAP)**

Hydrogels or superabsorbent polymers (SAPs) are effective at sorbing heavy metals, making them valuable as soil amendments to decrease metal mobility and plant uptake. Composed of loosely crosslinked hydrophilic polymer chains, hydrogels can absorb and retain aqueous solutions at rates up to hundreds of times their weight, which aids in water conservation in agriculture. The most commonly used hydrogels in this field are polyacrylamide and polyacrylate SAPs, which contain a high density of metal-chelating groups, allowing them to stabilize heavy metals in the soil and reduce their bioavailability.

## Cropping Pattern

The annual rotation and spatial arrangement of crops on the same land are vital for sustainable agriculture. Recogniz-ing that both controlled and uncontrolled wastewater disposal can contaminate soils and water sources and that pathogens and heavy metals can bio-transfer through the sewage-soil-vegetation-animal-human chain, various regulatory measures have been established to mitigate pollution. However, the long-term viability of irrigation with low-quality water relies on site-specific factors such as soil type, climate, crop selection, application methods and sociopolitical conditions, leading to efforts to optimize loading rates and improve water application techniques and produce quality. (Minhas and Samra, 2004). It is a cost-effective and eco-friendly technology with high public acceptance, phytoremediation is considered to be a promising purification method for contaminated water.

## Conclusion

The development and adoption of advanced technologies in wastewater management for agriculture hold the promise of addressing critical challenges such as water scarcity, environmental pollution and sustainable farming. Through recent technologies like bioremediation, phyto-remediation, constructed wetlands, nanoparticles, hydrogels, cropping pattern, wastewater can be transformed from a liability into a valuable resource.The integration of wastewater management technologies into agriculture is vital for achieving global sustainability goals, ensuring food security and preserving natural ecosystems.

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# Role of Male Sterility and Self - Incompatibility for Hybrid Seed Production in Flower Crops

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## Introduction

Hybrid seed production is essential for enhancing the quality, yield, and uniformity of flower crops. To create high-quality hybrids, controlled pollination is crucial to prevent self-fertilization and ensure cross-pollination. Male sterility and self-incompatibility are two key biological mechanisms that facilitate cross-pollination and are vital in hybrid seed production. These mechanisms help avoid inbreeding depression and maintain hybrid vigor. Hybrid seeds offer uniform plants with improved vigor, disease resistance, and ornamental traits. The F1 hybrid, the first generation of offspring from distinct parental types, is heterozygous and exhibits uniform characteristics. Producing hybrid seeds requires maintaining genetic purity in parental lines, often through hand pollination or male sterility systems such as genetic male sterility (GMS) and cytoplasmic male sterility (CMS). The development of hybrid seeds for ornamental flowers began in the 1960s by M/O Indo American Hybrids (India) Pvt. Ltd., which focused on petunia F1 hybrids for export. Successful seed production relies on careful parental line selection and controlled pollination, which is critical for ensuring genetic diversity, maintaining plant populations, and meeting commercial demands. Flowering annuals contribute significantly to garden landscapes with their vibrant colors and fragrances.

## Male Sterility in Flower Crops

### Definition and Types of Male Sterility

Male sterility is a condition where a plant is unable to produce or release functional pollen leading to an inability to self-fertilize. Male sterility can be classified into three main types:

### Genetic Male Sterility (GMS)

Also called "nuclear male sterility". Pollen sterility caused by nuclear genes, reported in Marigold, Zinnia & ageratum. Discovered by Lewis and Crow in 1956. The GMS are usually recessive and rarely dominant. Arisen due to spontaneous mutations, which occur frequently in flowerings plants. Commonly used mutagens were gamma rays and EWS (ethyl-methane sulphonate.) The GMS consists of two line

**A line:** which is a male sterile line (mm) used as female parent in hybrid seed production.

**B line:** it is a male fertile line (Mm) (used as male parent in hybrid seed production). This type is controlled by specific genes that disrupt pollen development. GMS is useful

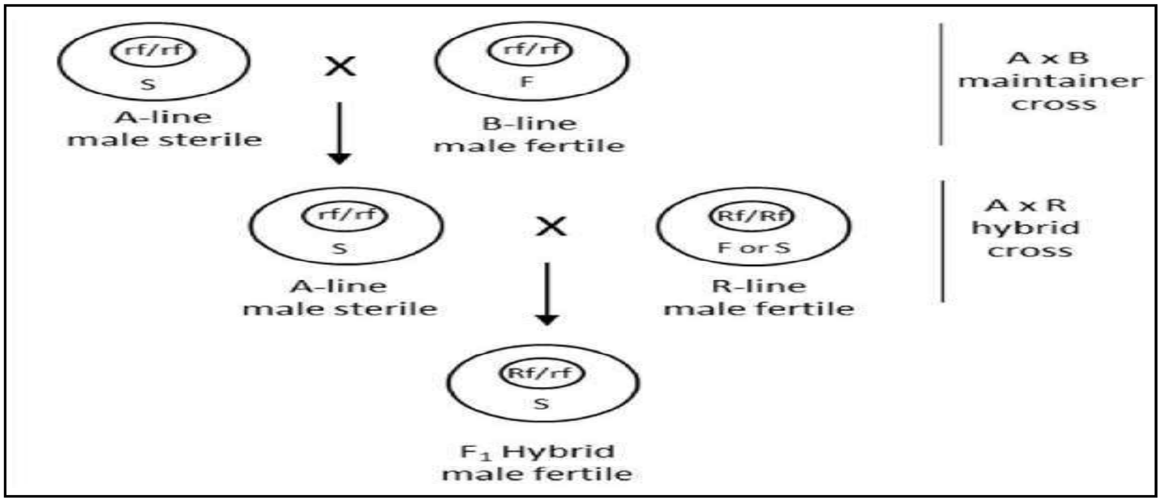


**Fig: Nuclear male sterility in Hybrid Seed production**

in hybrid production as it is inherited in a predictable Mendelian pattern. However, it often requires careful management, as homozygous recessive plants are sterile and need to be crossed with heterozygous or homozygous fertile lines to produce hybrid seeds.

**Cytoplasmic Male Sterility (CMS)**

It is controlled by cytoplasmic gene or a plasma gene is called Cytoplamic male sterility, reported in Chrysanthemum and Petunia. This system consists of twoinbred line A and B. CMS results from cytoplasmic factors, often in conjunction with nuclear genes, leading to sterility. CMS is commonly used in hybrid breeding as it is maternally inherited, making it stable across generations. CMS is frequently used in species like carnations and marigolds.

**Cytoplasmic genetic male sterility**

When the MS is controlled by both cytoplasmic and nuclear gene, it is called as Cytoplamic male sterility, reported in Petunia, Marigold, Zinnia, Cosmos and Sunflower. It was firstly reported by Johns & Davis in 1994. This system consists of three line- A line- Male sterile line, B Line- Male fertile line and R line-Restorer line. The CGMS is commonly used for hybrid seed production in both sexually & asexually propagated crops. It is highly stable & reliable.

**Other types of male sterility**

**1. Chemically induced MS:** Male sterility which is induced by use of some chemical agents is called chemically induced male sterility. eg. Sodium methyl arcenate (SMA), zinc methyl arcenate (ZMA) & mallic hydrazide etc.

**2. Transgenic male sterility:** Male sterility which is induced by genetic engineering that is incorporating foreign genes (transgenes) is called transgenic male sterility. e.g. 1$^{st}$ Blue rose Variety (APPLAUSE). In this system two types of genes are used

- **Barnase:** It cause male sterility and associated with A line.
- **Barstar:** It supress the male sterility gene (Barnase) and leads to restoration of fertility. It is associated to restorer line.

**Environment-Sensitive Male Sterility (EGMS):** Some flower crops exhibit sterility under specific environmental conditions, such as temperature or photoperiod sensitivity. This form of sterility allows breeders to control pollination by managing environmental conditions.

**Mechanism of Male Sterility:** Male sterility arises due to disruptions in pollen production, which can involve defects in pollen mother cells, sporogenous tissues or tapetal cells. In hybrid seed production, male sterile plants serve as the female parent and are crossed with pollen-producing plants, ensuring cross-pollination.

**Applications in Hybrid Seed Production:** Male sterility, especially CMS, is widely used in breeding programs for flower crops like petunias, marigolds and zinnias. By eliminating the need for manual emasculation, male sterility simplifies the hybridization process, reduces labour costs and improves the purity of hybrid seeds.

**Self-Incompatibility in Flower Crops**

**Definition and Types of Self-Incompatibility**

Self-incompatibility (SI) is a genetic mechanism that prevents self-pollen from fertilizing the ovule, promoting cross-pollination. There are two main types of self-incompatibility:

• **Gametophytic Self-Incompatibility (GSI)**: In GSI, the compatibility of the pollen is determined by its own genotype. This type is common in flowers like petunia, where self-pollen is rejected in the stigma or style, allowing only cross-pollen to fertilize the ovule.

• **Sporophytic Self-Incompatibility (SSI):** In SSI, the pollen's compatibility is determined by the genotype of the plant producing it, rather than the pollen itself. This type of SI is typically found in species with more complex pollination systems.

• **Mechanism of Self-Incompatibility**

In SI systems, interactions between specific proteins on the pollen and the stigma prevent pollen germination or pollen tube growth if both share the same genetic allele. This selective rejection mechanism ensures cross-pollination by encouraging pollen from genetically distinct plants to succeed.

• **Somatic embryogenesis**

The process through which somatic cells develop into somatic embryos is known as somatic embryogenesis. It is of 2 types- direct and indirect somatic embryogenesis.

**Steps for the production of F1 hybrid seeds**

1. Selection of inbred line
2. Testing their combining ability
3. Production of F1 hybrid performance.

**Methods of hybrid seed Production**

• Hand Emasculation and Pollination.

• Chemical Emasculation (dipping the panicles in hot water or treating with some chemicals such as Gibberellins, 2-4, D & NAA, etc.) these should not affect female fertility and normal growth of plants.

• Male sterility

• Self-incompatibility

• Somatic embryogenesis.

**F1 hybrid seed production in Marigold**

• The F1 hybrid seed in marigold was produced by using Apetalous male-sterile line.

• The male sterile-line & tester parent were grown in separate polyhouse.

• Apetalous male-sterile (a flower which have no petal) line were maintained.

• Crossing with respective tester parent from 9 to 2 pm by taking pollen from desirable male parent in a petri dish & dusting male sterile flower with the help of brush.

• The flowers were bagged with perforated Butter paper Bag.

• In French & African marigold tester were carried out by using tester parent.

• F1 hybrids seeds were collected & sown for Evaluation in subsequent season.

**Applications in Hybrid Seed Production**

Self-incompatibility is advantageous in hybrid seed production, especially in flower crops like petunia and snapdragon. It reduces the occurrence of self-fertilization and enhances hybrid purity. SI systems are often used in combination with other methods, such as hand pollination or the use of pollinators, to ensure successful cross-pollination.

**Fig: Hybrid Seed production in marigold**

**Advantages of F1 hybrid**

• Uniform in growth and yield.

• They outperform their parents in terms of yield and other desired features.

• F1 hybrids exhibit increased adaptability to various environmental situations since their genetic makeup is continuous and homozygous.

• The variety maintains consistency over a number of years.

• Dwarf and compact growth, numerous basal branches, early maturity and large sized blooms are produced in F1 hybrids of Petunia, Dianthus and Balsam.

• Doubleness in F1 hybrids of Petunia.

• Few additional benefits of F1 hybrids are production of dwarf and compact plants, numerous basal branching, abundant free flowering, earliness, a prolonged blooming season, doubleness, large-sized blooms, innovation in flower colour and shape, tolerance/resistance to abiotic and biotic stresses.

**Disadvantages of F1 hybrid**

• Due to narrow genetic base and uniformity, sometimes F1 hybrids exhibit minimum adaptability.

2. Due to inbreeding depression in F2 fresh hybrid seed has to be developed every season.

• More expensive.

• It needs more technical skills for hybrid seed production.

• Input requirement is more.

**Limitations**

Advantages of Using Male Sterility and Self-Incompatibility in Hybrid Seed Production

• **Enhanced Hybrid Vigor:** Ensures cross-ollination, producing hybrids with better growth, yield and quality.

• **Cost Efficiency:** Reduces labour and timeinvolved in manual emasculation, lowering production costs.

• **Increased Seed Purity:** Minimizes selffertilization, enhancing genetic uniformityand quality in hybrids.

**Limitations**

• **Dependency on Genetics:** The stability of male sterility and self-incompatibility mechanisms is highly dependent on genetic factors, which may not be available in all species.

• **Environmental Sensitivity:** Environment-sensitive sterility is less reliable, as changing cond-itions can lead to partial fertility, reducing the effective-ness of hybrid production.

## Hybrid Seed Production in Important Flower Crops

**Balsam:** Hybrid seeds are produced by emasculation technique. In Nauni, Seeds are produced every year by maintaining the double flowered seedling selection.

**Carnation:** Due to heterostyly i.e., length of the style is longer than filament of the anther, cross pollination is carried out to develop hybrid seeds. The developed seeds have to be harvested before the beginning of shattering.

**China aster:** It is a self-pollinated crop. But, due to dichogamy, the stamens and pistils do not mature at a time. This helps in promoting cross pollination by emasculating the disc florets and chopping the ray florets to the stigma level.

**Chrysanthemum:** Due to the protandrous and self-incompatibility conditions, it promotes cross pollination. In India, majority of chrysanthemum cultivars were produced by natural or artificial pollination and seedling selection.

**Dahlia:** Dahlia breeding is fairly easy since no emasculation or bagging is required. When mature, ray florets are glossy like those of other Compositae plants. With the use of a fine brush, one can manage pollination by moving pollen between the central disc florets of two flowers.

## Conclusion

Male sterility and self-incompatibility are powerful tools in the hybrid seed production of flower crops. By preventing self-fertilization, these mechanisms increase the quality and consistency of hybrid seeds, making them vital for commercial flower breeding programs. Their use, however, requires careful genetic management and sometimes environmental control. With advancements in molecular genetics, the use of these mechanisms can be optimized further, ensuring the development of high-quality flower hybrids for the global market.

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# Indigenous Technical Knowledge Used in Organic Livestock Production

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## Introduction

Indigenous Technical Knowledge (ITK), passed down through generations, is crucial to rural economies, significantly enhancing dairy farming and other livestock sectors such as poultry, sheep, goat and pig farming by offering sustainable and cost-effective solutions for animal health, nutrition and management. This knowledge is a key resource for landless, marginal and small farmers, significantly contributing to household income. Traditional dairy farming practices, rooted in indigenous knowledge, have long aided dairy producers in managing livestock. ITK, as noted by Singh and Tiwari (2004), is one of India's most valuable assets, serving as the foundation for a variety of activities, including farming, healthcare, food preparation, education and environmental conservation. ITK fosters creativity, particularly at the grassroots level.

India, a diverse country with numerous indigenous communities, harbors a wealth of traditional knowledge and technologies. Many of these practices are not only on par with contemporary scientific advancements but have also enabled indigenous tribes to live sustainably and autonomously. Indigenous knowledge, which emerges within a specific community, is typically communicated informally. It involves the use of locally available herbs, herbal products and other natural resources in rural veterinary practices. These treatments are often viewed as effective, free from side effects and economically viable (Talukdar *et al.*, 2012).

Indigenous knowledge is unique to the geographic area in which it develops and addresses local problems through the innovative use of available resources. As defined by Grenier (1998), ITK is the distinctive local knowledge developed by indigenous women and men in specific environmental and social conditions. Harun-or-Rashid *et al.*, (2010) emphasize that ITK is locally accessible, cost-effective, socially compatible and economically sustainable. Farmers believe in its efficacy and reliability, reinforcing its continued use.

The role of ITK extends beyond economic benefits, also addressing health-related issues for both humans and animals, such as nutrition and disease management. However, one of the main challenges with indigenous knowledge is its lack of formal documentation, as it is often passed down orally through generations (Devaki & Mathialagan, 2015). This makes it vulnerable to loss if not properly recorded and transmitted (Borthakur & Singh, 2012).

Indigenous Knowledge (IK) refers to the unique, traditional knowledge developed by local communities over generations through direct interaction with their environment. It encompasses the skills, practices and wisdom used in various aspects of life, including agriculture, healthcare, natural resource management and cultural activities. This knowledge is often passed down orally and is deeply rooted in the social, cultural and environm-ental contexts of the community, offering sustainable, locally adapted solutions to everyday challenges.

**Objectives of ITKs in organic livestock Production**

Indigenous Technical Knowledge (ITKs) in organic livestock production focuses on promoting animal health and welfare through natural remedies and preventive measures. Research on organic livestock has increased significantly since 2005, with animal welfare and health being key areas of focus (Manuelian *et. al.*, 2020). ITKs offer benefits such as cost-effectiveness, availability of raw materials and minimal side effects compared to conventional medicines (Shubeena *et. al.*, 2022).

However, organic systems face challenges in managing healthrelated issues, necessitating the development of scientifically evaluated, organically acceptable treatments. While ITKs are still widely used, especially among traditional communities like the Tharu tribes, there is a need for documentation and validation of these practices to ensure their effectiveness and preservation (Mukherjee *et al.*, 2022).

Organic livestock farming promotes sustainability, biodiversity preservation and environmental balance through the use of indigenous technical knowledge (ITK) and local resources. It emphasizes the integration of livestock management with soil health improvement and cultural preservation (Battaglini *et. al.*, 2014). ITK practices in livestock rearing contribute to low-cost management, improved product quality and suitability for organic farming. Organic livestock production focuses on animal health, restricted use of antibiotics and hormones and access to pasture. The approach aims to conserve genetic resources, maintain landscapes and provide ecosystem services. However, challenges exist, such as higher mortality rates in native breeds. Despite these challenges, organic livestock farming offers a holistic approach to sustainable agriculture, balancing environmental, economic and cultural considerations while preserving traditional knowledge for future generations (Saini *et. al.*, 2018).

**ITKs Used for Health Management in Livestock**

| Condition | ITK Practice/Formulation |
|---|---|
| Anorexia | Mixture of powdered fennel seed (*Foeniculum vulgare*) + jaggery (60g each) + black salt (20 g), applied as electuary. |
| | Mixture of powdered ajwain (*Trachyspermum ammi*) seeds + salt (20g each) in 20 g molasses, given orally twice daily. |
| Rumen Indigestion | Magnesium sulphate (500 g) + common salt (200 g) + ginger (*Zingiber officinale*) powder (10 g) in 500 ml lukewarm water, orally. |
| Constipation /Purgation | Vegetable oil (500 ml) given orally to adult cattle. |
| | Decoction of turmeric (*Curcuma longa*) powder (100 g) in water, given daily for 2-3 days. |

| Condition | ITK Practice/Formulation |
|---|---|
| Bloat | Vegetable oil (500 ml) + Asafoetida (Ferulafoetida) (10 g) + black salt (20 g) + tulsi (*Ocimum sanctum*), orally for adult cattle. |
| | Asafoetida (5 g) + black salt (100 g) + dill (*Anethum sowa*) seed (50 g) + ginger powder (25 g) + ajwain boiled in water, orally. |
| Diarrhea | Black wood (*Dalbergia sissoo*) leaf powder (70-100 g per 100 kg body weight) given orally to calves. |
| | Powder of half-ripe bael (*Aegle marmelos*) (15-25 g per kg body weight) given orally to calves. |
| | Kaolin (5 g) + prepared chalk (5 g) + catechu (0.8 g) + bael (1 g) + a lum (0.8 g) + Cyperus (2 g) + connessi bark (3 g), orally. |
| Prolapse | Prolapsed part is washed with cold water or sugar water, cleaned and manually replaced, sometimes lubricated with mustard oil. |

**ITKs for Fertility and Reproductive Health**

| Condition | ITK Practice/Formulation |
|---|---|
| Increasing Fertility | One kilogram of onions (*Allium sepa*) mixed with salt is fed monthly. Garlic is sometimes added.<br>Mixture of fenugreek seeds (*Trigonella foenumgraecum*) (20 g) and almonds (10 g) boiled in 1 kg of milk, fed to animals. |
| Repeat Breeding | 50 g of henna (*Lawsonia inermis*) powder mixed with water and fed after artificial insemination.<br>Heated alum (Fitkiri) is given orally twice a day.<br>Preference for natural service (local bull) over artificial insemination in cases of repeat breeding. |
| Prolapse Management | Cold water and sugar solution applied to the prolapsed part to reduce swelling, with mustard oil for lubrication during retraction. |

**ITKs for Newborn Care**

| Condition | ITK Practice/Formulation |
|---|---|
| Care for Newborn Calf | A raw egg is given daily to the newborn calf for a month.<br>Mixture of raw egg, banana and traditional tea (pink tea of Kashmir) used as milk replacer when the dam cannot nurse the calf. |
| Constipation in Calves | Bolus of common mallow (*Malva sylvestris*) (30-50 g) is given once a day to relieve constipation. |
| Dehydration/ Diarrhea in Calves | Electrolyte solution of sugar, salt and sodium bicarbonate is administered 3-4 times daily if the calf is suffering from diarrhea. |

## Conclusion

ITKs serve as an invaluable resource for organic livestock production, offering natural, cost-effective and sustainable alternatives to modern veterinary practices. By using these traditional methods, organic farmers can maintain livestock health and productivity without resorting to synthetic chemicals or pharmaceuticals, aligning with the principles of organic farming and sustainability.

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# Microplastics and Their Impact on the Aquatic Environment

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## Introduction

Increased productivity and slow biotic decomposition of plastic led to its accumulation in the environment leading to adverse effects in aquatics. The plastics entering into the marine environment may remain for hundreds and thousands of years, during which they get fragmented due to the mechanical and photochemical processes resulting in the formation of microplastics (< 5 mm) or nanoplastics (< 1 μm).

### Microplastic

Microplastics are fragments of any type of plastic less than 5 mm in length. Microplastics are ubiquitous and slow degrading contaminants with properties such as long residence time, high stability, high potential of being fragmented and the ability to absorb other contaminants. Most microplastic pollution comes from textiles, tires and city dust which account for over 80% of all microplastic in the environment.

### Classification of microplastics

Two classifications of microplastics are currently recognized.

**a) Primary microplastics:** Primary microplastics include any plastic fragments or particles that are already 5.0 mm in size or less before entering the environment. These include microfibers from clothing, microbeads and plastic pellets.

**b) Secondary microplastics:** Secondary microplastics arise from the degradation (breakdown) of larger plastic products through natural weathering processes after entering the environment. Such sources of secondary microplastics include water and soda bottles, fishing nets, plastic bags, microwave containers, tea bags and tire wear.

• Both types are recognized to persist in the environment at high levels, particularly in aquatic and marine ecosystems, where they cause water pollution.

### Microplastics: Distribution

Microplastics into the aquatic systems occurs through disparate sources and pursue multiple pathways. The sources relate to the manufacturing of plastic products water and sewage treatment plants industrial or agricultural wastes, weathering of plastics, fisheries or aquaculture that may enter into the marine system affecting the aquatics. The existence of microplastics in the environment is often established through aquatic studies. These include taking plankton samples analyzing sandy and muddy sediments, observing vertebrate and invertebrate consumption and evaluating chemical pollutant interactions. The micro-plastics are released into the aquatic environment from multiple sources, commonly from the degradation of larger plastic items found in various environmental compartments due to poor plastic waste management.

**Effects of Microplastics**

Microplastic when consumed by aquatic species, gets bioaccumulated, there by displaying particle or chemical toxicity and mixture effects contributing to disturbance in their metabolism, feed patterns, development and reproduction with differing degrees of toxicological risks for each species.

• Microplastics results in their uptake by a wide range of aquatic species disturbing their physiological functions, which then go through the food web creating adverse health issues in humans.

• Intake of Microplastics by marine animal's results in higher toxicity due to the aggregation of organic hydrophobic compounds.

• Effects of Microplastics uptakes result in reduced food intake, developmental disorders and behavioral changes.

• As humans are the ultimate consumers of sea foods which are highly affected by microplastics, there is a high chance of microplastic transfer to humans.

• For example, polystyrene concentration resulted in diminished chlorophyll concentration in algae whereas Daphnia magna displayed impairment in reproductive cycles.

• The chronic effects of microplastics can be pass on to successive level throughout the food chain, negatively affecting the organisms. The effects of microplastics vary with the organism species and microplastic type and concentrations.

• The presence of microplastics detected at all stages in the food web affecting the gastrointestinal tracts and tissues.

**Case Study on Microplastics**

• Bessa *et. al.*, (2019) studied the plastics debris gets cumulated in the guts of penguins preventing it from the consumption of food and also results in the absorption of toxic substances from water, thus affecting their growth and development.

• Sussarellu *et. al.*, (2016), showed the adverse impact of polystyrene microplastics on reproduction and feeding of oysters due to amendation in their food intake and energy distribution. On exposure to micro-sized polystyrene, oyster showed a reduction in number of eggs produced, ovocyte quality and sperm motility.

**Sources of figure: 1.Food Safety Snapshot: Microplastics in Food**

**2. https://truewater.com.au/microplastics-in-sewage**

• Cole *et.al*., (2015) showed how ingestion of MPs affected the feed habit, fertility and functioning of zooplanktons like copepods *Calanus helgolandicus.*

### Strategies and Management

• The destructive impacts of microplastics, low cost, high-quality and environmentally sustainable plastic waste management is required.

• The removal and biodegradation of microplastics from water and aquatic systems are still limited in the laboratory which can be commercialized under large scale using microorganisms such as fungi, protozoans and bacterial spores in the future.

• Methods can be implemented before the microplastics get converted into nanoplastics by segregating the high-density plastics that accumulate at the bottom and the low-density plastics that float at the surface of the water, to prevent further aquatic contaminations.

### Policy and Legislation

It is important to monitor the excessive use of plastic additives and to enact laws and standards to control plastic litter sources due to the resulting danger of Microplastics to marine biota. With increasing awareness of the detrimental effects of microplastics on the environment, groups and organization are now help for the removal and ban of microplastics from various products. One such campaign is "Beat the Microbead", which focuses on removing plastics from personal care products. UNESCO has sponsored research and global assessment programs.

### Conclusion

Plastic polymers are inseparable items from people's lives as plastics' demand increases in direct and indirect applications. The plastic is released into the environment which breaks into smaller debris (microplastics) due to environmental factors and transport to water bodies. It is essential to establish models with the help of data and practical verification to understand the transport and the risk assessments of microplastics in order to maintain healthy ecosystems.

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# Micro-Irrigation: A Boon for Horticulture in the Era of Water Scarcity Due To Climate Change

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## Introduction

Providing irrigation to the cultivated horticultural and agricultural crops is an important input which determines the yield potential. But, unfortunately, the climate change has created the water scarcity/drought condition. So there is need to adopt new technique of irrigation to minimise or avoid the loss of water during cultivation than the traditional methods of irrigation. Micro-Irrigation System (MIS) specially Drip irrigation and sprinkler irrigation is becoming popular among the growers because of it high water use efficiency, cost-effective, high fertilizer use efficiency *etc*. This system should be promoted and adopted more for increasing the income of farmers and for sustainable horticultural production.

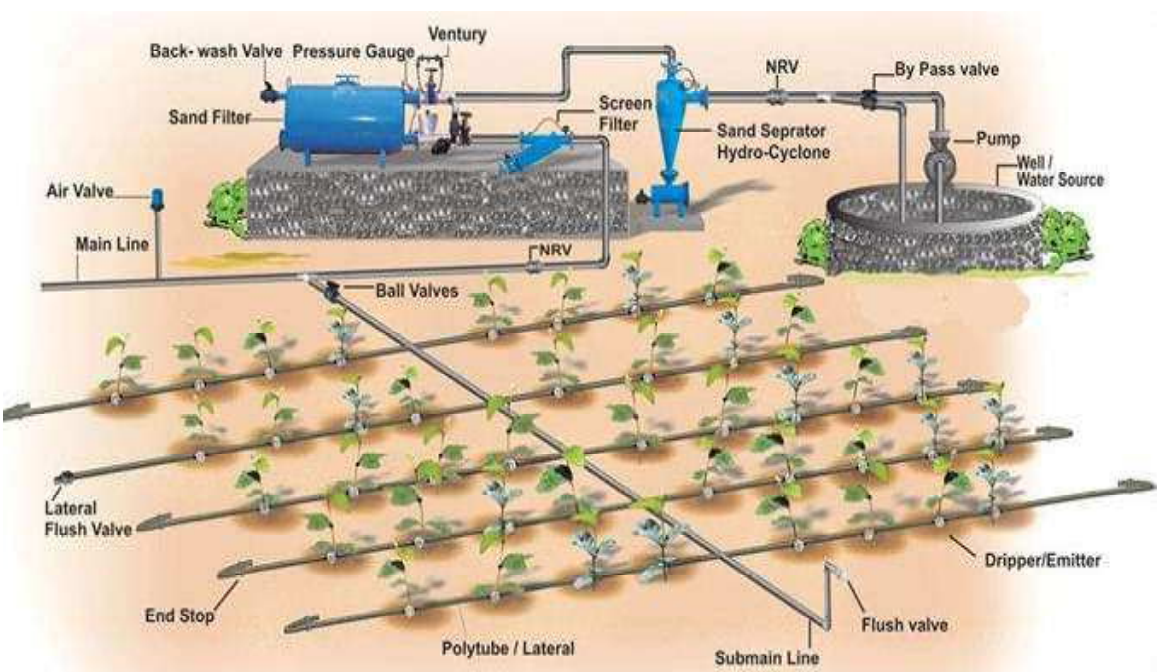


**Figure 1. Layout of Drip Irrigation (*Courtsey*: Jain Irrigation)**

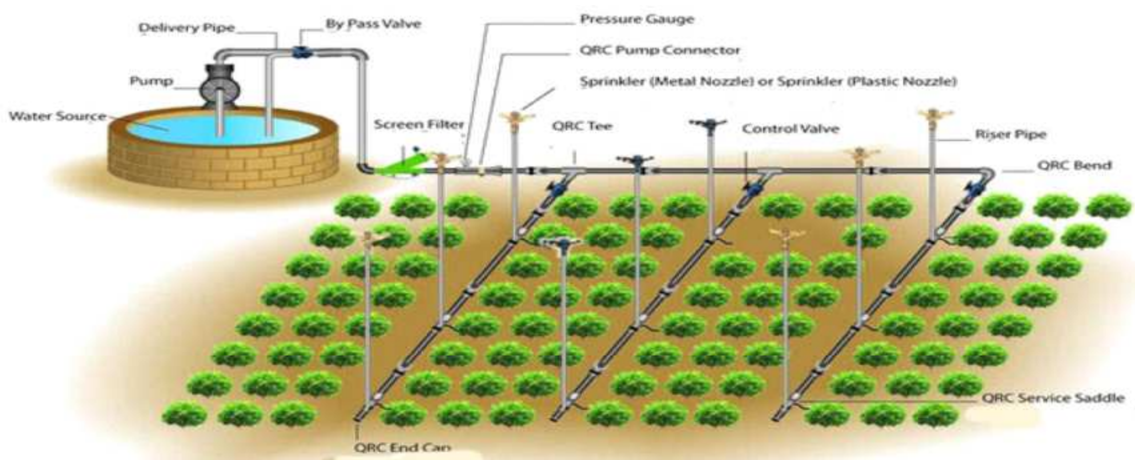


**Figure 2. Layout of Sprinkler irrigation (*Courtesy: https://vietkidsiq.edu.vn*)**

## Discussion

National Committee on Plasticulture in Agriculture (NCPA) sanctioned use of plastic material in agriculture in 1981. That emphasized on the promotion of plastic for greenhouses, mulching and drip irrigation for supporting horticultural crops productivity. So, with this connection, GOI brought CSS (Centrally Sponsored Scheme) for the promotion of plastic and initiated the MIS (Micro Irrigation System) in agriculture in 1992. In 2006, the Ministry of Agriculture's Department of Agriculture and Cooperation introduced CSS in micro irrigation. And it was renamed as NMMI (National Mission on Micro Irrigation) in 2010. After that NMSA (National Mission on Sustainable Agriculture) was merged with NMMI in 2014. This started conducting On Farm Water Management (OFWM). Later the micro-irrigation component of OFWM merged with Pradhan Mantri Krishi Sinchayee Yojana-Per Drop More Crop (PMKSY-PDMC) in 2015 that further promoted and

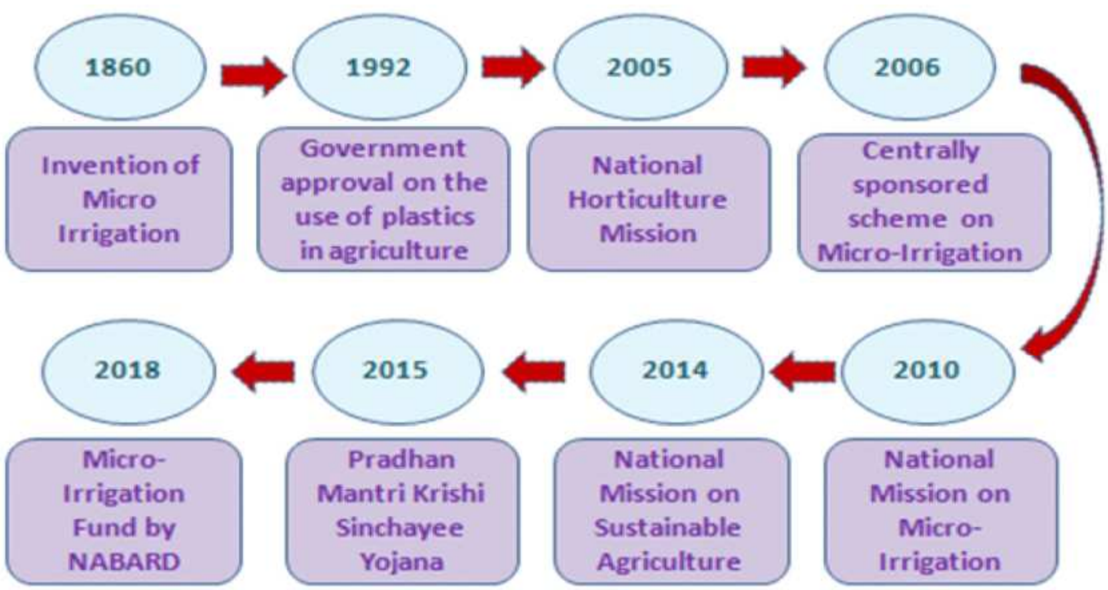


**Figure 3. Journey of Micro Irrigation System in India**

strengthened the use of micro-irrigation in agriculture and hortic-ulture. Later on to cover the irrigated area under Drip and Sprinkler system, NABARD has created Micro Irrigation Fund (IMF) for providing initial installation cost to farmers at subsidized rates. Both, the central and state governments are promo-ting micro-irrigat-ion with subsidy aspect. The nodal agricult-ural body like ICAR has been involved from years in the promotion, awareness, guidance to the farmers through various KVKs spreaded throughout the country under the Per Drop More Crop Yojna.

As per the land used availability, the net sown area of India is 141.1 m ha (2021-22) out of which 73 m ha area is net irrigated. Approximately 48% of net sown area of India is needed to have irrigation. Which is emphasizing on need to expand our irrigation facility to those cultivated areas which are totally dependent on the rainfall for irrigation. In India, the total area under micro-irrigation is 14.49 m ha (2021-22) out of which under drip irrigation (6.67 m ha) and under sprinkler (7.81m ha). Maharash-tra is having maximum land coverage under drip irrigation which is followed by Andhra Pradesh, Gujarat and Karnataka respectively. Where as under sprinkler irrigation, Rajasthan occupies maximum area followed by Karnataka, Gujarat and Haryana respectively (DAFW, 2022). Looking into the adoption of micro-irrigation (both drip & sprinkler), Karnataka ranks first, followed by Rajasthan, Maharashtra and Andhra Pradesh as represented in the figure 4.

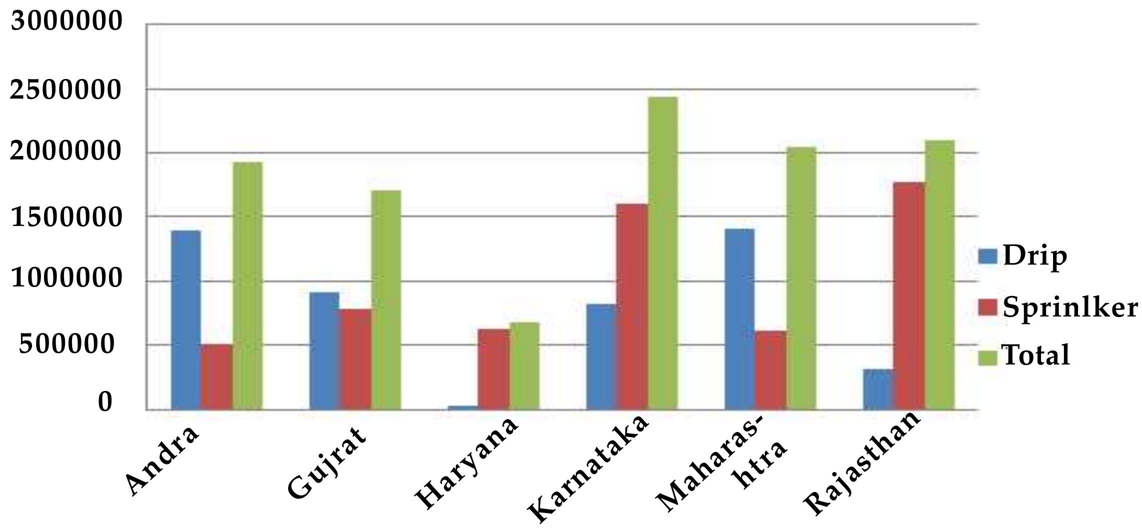


**Figure 4. State-wise area (ha) coverage under Micro Irrigation as on 31.03.2022 (Source: Department of Agriculture & Farmers Welfare)**

With the initiative of government scheme, the adoption of drip and sprinkler irrigation has increased. The total area under drip and sprinkler was 7.78 m ha during 2014-15 but it has increased to 14.48 m ha in 2021-22 as presented in figure 5.

Drip irrigation and sprinkler irrigation are most popular methods of micro-irrigation. In Drip nutrients and water are delivered directly to the root zone of plants. Drip irrigation system ensures the correct amount and time of application of inputs to the root zone of crops which results into the optimum growth and development of plants. This system is useful where the availability of water is very limited and mostly suited for crops having widersp-acing. Drip irrigation method is used for vegetables like cauliflower, radish, brinjal, capsicum, tomato, okra, cucumber, lettuce, ash gourd, potato, citrus, mango, aonla, grapes, ber, pomegranate, marigold, china aster, chrysanthemum, carnation, gerbera and orchid, etc.,

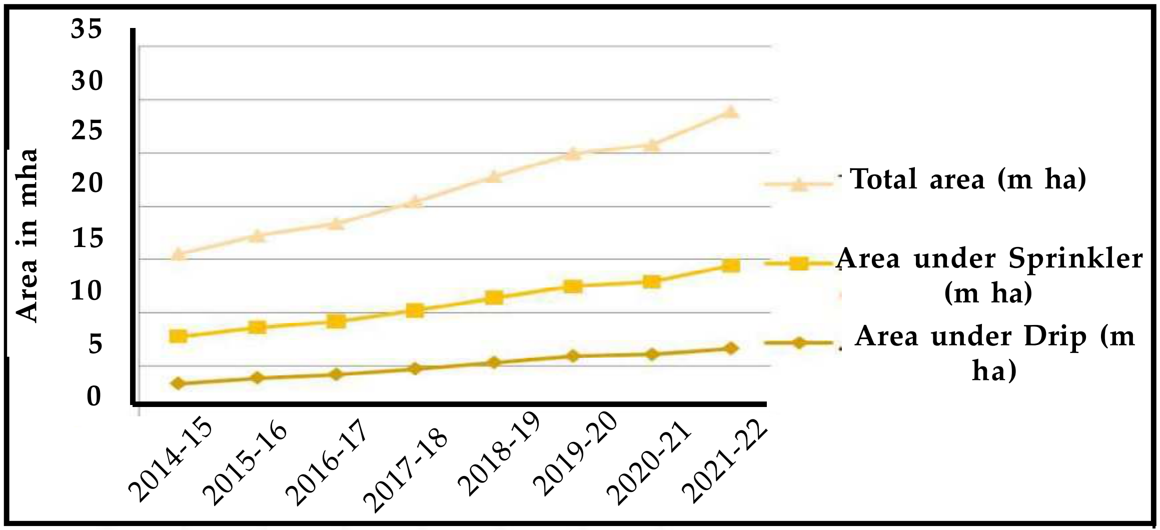


**Figure 5. Trend of coverage of drip and sprinkler irrigation in India from 2014-2022 (Source: Department of Agriculture & Farmers Welfare).**

The major components of drip irrigation consists of filters (types: Media, hydrocyclone, screen and disc), main line (consist of sub main and laterals), drippers/emitters (online and inline), fertilizing unit, pressure gauge, control valves, non-return valves, air valves etc., The emitters in drip irrigation system contains plastic dripper fitted on the plastic drip lines or laterals having various emission capacity with slow and steady rate. These emitters dissipate water pressure through the use of long-paths, small orices. The emitters of drip irrigation are present with the emitting capacity of 4 lph (liters per hour) and 2 lph (liters per hour).

**Installation of MIS**

**Disc Filter of MIS**

**Sub-mains connected to valves**

**sub-mains connected to laterals**

**Components of MIS**

In sprinkler irrigation system water is sprayed / sprinkled / misted on soil. This type of irrigation is also known as over head irrigation and that is why it may be compared to the natural rainfall. In this system water is sprayed through various pipes with the help of pumping of motor. The water under pressure is allowed to rise up through riser.

The end of riser is fitted with sprinkler that sprayed the water after breaking it into small droplets. The coverage area of sprinkler may be more than 10 meters and more than 1000 lph (litres per hour) watercan be sprinkled through it. The sprinkler which is fitted to the riser may be of perforated and rotating type. This system of micro-irrigation may be installed permanently and can be kept portable according to the convenience. Water source, pumping unit, main lines, lateral lines, risers and sprinklers are the major components under this modern technique of micro-irrigation. Now a day's several variants of sprinkler irrigation systems are available in market. Sprinkler irrigation is very much useful where foliar applications of nutrients are needed, seed germination in nurseries etc., are required.

**Table: 1. Comparison between conventional irrigation and micro-irrigation systems**

| Comparison parameters | Conventional Irrigation system | Micro Irrigation system |
|---|---|---|
| WUE | 35-50 % because of more water loss | 60-95% |
| Soil type | All types of soils are not suited | Suitable to all soils |
| Fertilizer use efficiency | Low | High as no leaching and runoff |
| Soil erosion & weed infestation | High | Soil surface is less wetted preventing soil loss |
| Pest & diseases incidences | More | Less |
| Control over irrigation water | Inappropriate | Precise |
| Labor utilization | Labor intensive | Machine intensive |
| Cost of irrigation | Low | High because of initial installation cost |

**Importance of Micro-Irrigation**

Micro-irrigation is being popular because of its property of slow and continuous application of irrigation water in form of droplets, miniature sprays above or below the soil. Which minimizes the wastage of water and increases the water use efficiency as compared to the traditional methods of irrigation. Moreover, micro-irrigation can be used in all sort of land, especially where flood method of irrigation is not possible. It is also advantageous to use micro-irrigation in hills, undulated land, barren lands and the areas having shallow soils. On the basis of depth soil can be classifies as deep soil (> 45 cm), medium soil (22.5-45 cm) and shallow soil (< 22.5 cm). Apart from its increasing water use efficiency (60-95 %), micro-irrigation system can be used for fertilizer application (fertigation) directly to the root zone of plants and can save the fertilizer up to 40%. Drip irrigation helps in suppression of weed growth in the cultivated land as the proportion of wet area reduces. This may further help in the control of spread of pest and in turn reduces the incidences of various diseases. All these benefits of micro-irrigation help in yield enhancement. The yield of fruits can be enhanced up to 40% and for vegetables it can be enhanced up to 51%. The unique and advantageous features of micro-irrigation system over traditional one, making it as an integral part of the concept of precision farming today. The GPS based computerized irrigation and chemical application technology can be possible through the self propelled drip and sprinkler irrigation system. That can apply the inputs on the basis of soil and plant requirement status.

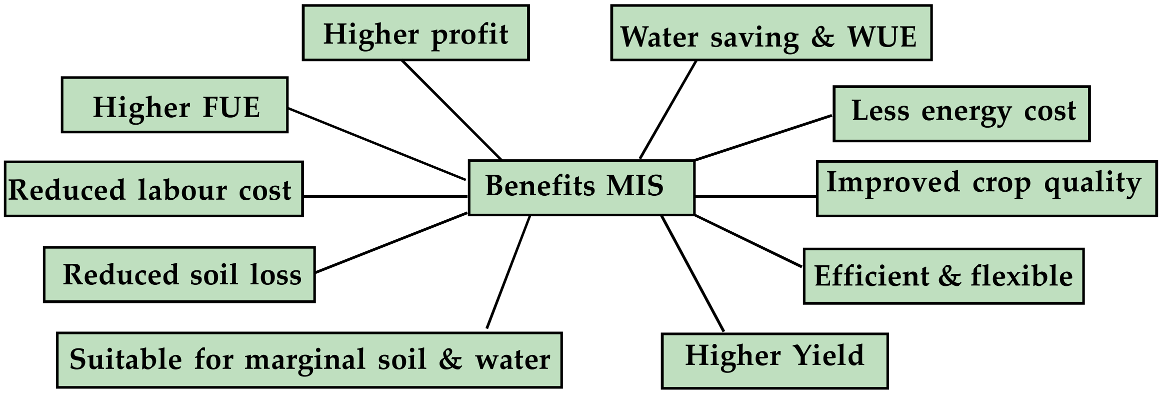


**Figure 7. Benefits of micro-irrigation system (MIS)**

## Constrains In Micro-Irrigation

In spite of being efficient in irrigation, better nutrient delivery and other features, MIS has certain constraints also. The initial installation cost of this new technique is high. It requires regular maintenance as there is clogging of pores of the emitters due to precipitation. The life of plastic material is less due to the damage by rodents, cracking and other factors. That also needed to be taken care. A cultivable land installed with micro-irrigation system leads to the difficulty in inter-cultural operations. The foliar application of nutrients and water sometimes can cause burning effect to leaves, may detoriate the quality of flowers and fruits and reduced the total yield. Farmers are not much awared about the use of micro-irrigation.

## Conclusion

In nutshell, the use of micro-irrigation system is advantageous in terms of low input utilization specially irrigation water and precise application of nutrients. This leads to the reduction of cost of cultivation and enhancement in the yield of the horticultural crops. Micro-irrigation cover all types of soil, reduce weed, helps in germination, better application of fertilizer, weedicide and insecticide. These modern techniques of irrigation has huge potential for a sustainable horticulture production but it must be supported with adequate awareness among farmers, proper training to farmers, financial aid for initial installation, regular maintenance and monitoring.

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# Value Addition of *Asparagus racemosus* Roots for Strengthening Rural Livelihood

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## Introduction

*Asparagus racemosus* (satavar, satavari, shathamul) is a woody climber or herb which has been used for centuries in Ayurveda as an aid for the reproductive system. It is common throughout, Nepal, Sri Lanka, India and the Himalayas. It grows one to two meters tall and prefers to make root in gravelly, rocky soils high up in piedmont plains at 1300-1400 meters elevations (Singh *et. al.*, 2003). Most of the herbal medicines are having a good response in the treatments. *Asparagus racemosus* Willd belongs to the family Aspragaceae traditionally used as anthelmintic, antiseptic, antidiarrhoeal and antidysenteric (Dhiman, 2005). This plant is recommended in Ayurvedic tests for prevention and treatment of gastric ulcers, dyspepsia and as a galactogogue. *A. racemosus* has been successfully employed by some ayurvedic practitioners for inflammation, nervous disorder, liver diseases and certain infectious diseases. Satavari have enormous medicinal and pharmaceutical value. A few recent reports demonstrated some additional beneficial effects of this herb including antihepatotoxic, immunomodulatory, immunoadjuvant and antilithiatic effects (Alok *et. al.*, 2013). Its roots also contain sitosterol, 4, 6-dihydryxy-2-O (-2-hydroxy isobutyl) benzaldehyde and undecanyl cetanoate (Sharma *et. al.*, 2009). Generally, its roots are sold in local markets and ayurvedic preparations through middle men. The value addition of roots by preparation of an Awaleh can be recommended through establishment of small scale industries may strengthen rural livelihood.

Thus, to study processing technique of value addition of *Asparagus racemosus* roots for preparation of Satawari Awaleh and marketing of packaged product, efforts have been made in Prayagraj district with a view to study detailed methodology as well as its trade and marketing for extending the technology in other areas for employment generation to the local farmers for strengthening rural livelihood. The Satavari Awaleh (Chyawanprash) is a nutritive jam, offering a wide range of health benefits. It is usually consumed directly or along with milk or water. It is marketable in a sealed container at a local market.

**Processing technique of Satavari Awaleh from roots of *Asparagus racemosus***

**Collection of roots:** Roots were collected by plants aged about one and half year old from a farmhouse. The roots were thoroughly washed in running tap water and water was removed by drying in shade. The thin rootlets were removed before processing.

**Washing and air drying of roots:** The roots were thoroughly washed in running tap water and water was removed by drying in shade. The thin rootlets were removed before processing.

**Peeling and pulping of roots:** The roots were steamed for a short time and the peel was removed. The peeled roots were processed in pulping machine for making a pulpy juice of roots. The boiled pieces of roots of *Asparagus racemosus* (satavar) is filled inside the pulping machine. The extracts of the pulp which is collected in the collection vessel connected to the machine and the materials left after the collection of the pulp is collected in the separate container (vessel) which is attached on the side of the pulping machine. Similarly, pulp of Aonla fruits was also extracted. The pulp of Satavar roots and Aonla fruits in 1:1 ratio was used.

**Processing of pulp:** The pulp was cooked for one and half hour at a normal temperature (40-50$^oC$). The constituents added during cooking were (a) Satavar root pulp (b) Aonla fruit pulp, (c) Sugar, (d) For 10 kg of satavari chyawanprash, 500gm of ghee was used for increasing the taste and quality of the product, (e) Dry fruits and cardamom powder (choti elaichi) were also used to add more flavour to the product. Certain preservatives were also used like potassium meta-bisulphide.

**Ratio of the constituents**

Aonla + Satavar = 1:1, Pulp + Sugar = 1:1

**Cooling:** Cooling is the process which includes the cooling of hot and cooked syrup of pulp containing all the ingredients (satavar, Aonla, sugar, potassium metabisulphite, ghee, resin & cardamom).

**Packing and Sealing:** The cooked material after cooling was filled in plastic bottles or containers. The bottle or the container caps were sealed tightly with the help of sealing machine and the pasting of the trademark of the industry. The product can be retailed at market rate in different packing.


**Results and Discussion**

*Asparagus racemosus*, a climbing Ayurvedic plant, is known for its numerous activities such as hyperlipidemia, hypertension, angina, dysmenorrhea, anxiety disorders, benign prostatic hyperplasia (BPH), leucorrhoea and urinary tract infections. This plant possesses a wide range of secondary metabolites inclusive of steroids, alkaloids, dihydrophenanthrene deriva-tives, flavonoids, furan derivatives and essential oils. Information from the literature suggests that, the major constituents of *A. racemosus* are steroidal saponins which are mainly responsible for different biological activities of *A. racemosus* (Singla & Jaitak, 2014).This awaleha has the drugs which possesses properties such as sthanya janana and sthanya shodhana (galactogogue) properties, which is useful in lactating mothers. This can also be administered in dysmenorrhoea (Painful menstruation), irregular and delayed menstrual cycles. It is also found beneficial in pre menopausal syndrome and post menstrual syndrome. It reduces the teekshnata of pitta, parinama shola (duodenal ulcer), burning and painful urination and in mouth ulcers. The recommended dose of the awaleh is 5-10 gms with milk or water twice daily. The product can be marketed through Khadi Gramodyog/ ayurdedic medicine industr-ies. The plant has numerous therapeutic applications viz. antioxidant, diuretic, antidepressant, antiepileptic, antitussive, anti-HIV, immunostimulant, hepatoprotective, cardioprotective, antibacterial, anti-ulcerative, neurodegenerative. The major studies were reported using extracts of the plant; still the active principle involved behind these activities needs to be explored. The formulations containing *A. racemosus* as the major ingredient against numerous disorders indicate its economic and therapeutic importance worldwide. The safety profile analysis showed that the *A. racemosus* is safe in therapeutic doses and can be used during pregnancy with a caution. As the value of medicinal plants depends on the active principles present in it, so the uniformity in quality as well as the quantity of planting material is of paramount importance.

## Recommendations

The processing technique is very simple and a good margin (> 50%) can be gained from this business at commercial level. The Satavar can be grown on cultivable land of farmers as well as on available spaces of tree orchards, as the main harvestable product is under ground and not much sun light is required for the growth. Thus, cultivation of this crop under orchards is good way of land utilization. Thus, this type of industry for manufacturing of Satavar awaleh can be easily established at village level for economic strengthening of farmers and the technique can be well extended to farmers of other region.

## Conclusion

There is not much significant adverse reactions have been reported in the doses of root powder used clinically. Shatavari can be grown on soil for dry land management. In India more than 500 tons of shatavari roots are needed every year for various medicinal preparations. A single plant may yield about 500-600 grams of fresh root. On an average, 12000-14000 kg of fresh roots can be harvested from an area of one hectare which on drying may yield about 1000-2000 kg of dried roots. Due to its multiple uses, the demand for *Asparagus racemosus* is constantly on the rise. Therefore, it is suggested that training on preparation of this commercial product of *Asparagus racemosus* and its cultivation at larger level may play a vital role in improving the economic strengthening of rural people.

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# Effects of Humic Acid Based Biostimulants

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## Introduction

Rice (*Oryza sativa*) is essential to the lives of billions of people around the world. It is one of the most widely consumed staple foods, produced and consumed in Asia. Probably the ancient grain to becultivated (around 10,000 years old), it accounts for 15% of protein and 21% of global human energy per individual l (Jha *et. al.*, 2024). Rice is a great source of energy because it is mostly made up of carbohydrates. Fiber though brown rice has high fiber than white rice; both types have a good source of iron, magnesium and B vitamins. Along with having a lower glycemic index than white rice, brown rice is a good source of dietary, which may help diabetics. Rice is a major crop in India. In the kharif and rabi/summer seasons, 43.4 million hectares of the 141 million hectares of land under cultivation are used for rice farming (Shetty *et. al.*, 2013). Humic acid based biostimulants play a vital role in increasing rice yields through the plant health promotion and the improvement of soil structure by aggregation, aeration and water retention; important factors for rice paddies (Chen *et. al.*, 2004). It increases required nutrients including nitrogen (N), potassium (K) and phosphorus (P) availability to the plants. In addition to, humic acid promotes the activity of the beneficial soil microbes, creating a more vigorous soil environment that accelerates plant growth.It can also stimulate plant hormone, increasing seedling development, flowering and grain filling that contribute to greater yields (Hernández *et. al.*, 2023).

The purpose of this review paper is to provide an overview of the humic acid based biostimulant (Sufalan and Shree Briddhi, products of NOP Natural Organic Products Pvt. Ltd.) effects of on rice grown in kharif season. It also looks at the limitations of the current research and identifies important topics for further investigation.

## Materials and Methods

### Experimental site and soil information

The field experiment was conducted in the Kharif season of 2024 on inceptisol at C Block Fulia Seed Farm of Nadia district, of West Bengal in India situated in New Alluvial Zonetoevaluate the efficacy of Sufalan and Shree Briddhi Biostimulant on growth and yield of rice.

The soil of the site was sandy clay loam with pH 7.04, organic carbon 0.45%, total nitrogen 188.9 kg $ha^{-1}$, available $P_2O_5$ 26.29 kg $ha^{-1}$ and available $K_2O$ 148.72 kg 0 $ha^{-1}$. The climate ofthe region is humid subtropical. The experimental plot was provided with assured irrigation facility having uniform topography and proper drainage. The experimental site is located at 23.2344°N latitude and 88.5062°E longitude 15 m above mean sea level.

### Treatments

The experiment was mapped out in paddy field with six treatments including two controls (untreated). The treatments are described in Table 1 briefly. $T_1$, $T_2$, $T_3$,$T_4$, $T_5$ and $T_6$ denotes the number of treatments, whereas $C_1$ and $C_2$ represents control 1 and control 2 respectively

The number of mature grain in experimental plot is 280 where the immature grain is 9 in T5. In control the number of mature grain is 280 whereas the immature is 31 in T1. In average result, in experimental plot the mature grain is 221 where the immature is 6 and in control plot the average mature grain is 157 where the immature is 84 (Table 2).

**Table 1: Treatment details for the field experiment**

| Treatments | Time of application | Recommended product | Dosage |
|---|---|---|---|
| T1 | At the time of transplanting | Sufalan | 8ml/ltr |
| T2 | 30 days after transplanting (DAT) | Sufalan | 8ml/ltr |
| T3 | 45 DAT | Sufalan | 8ml/ltr |
| T4 | 65 DAT | Shree Briddhi | 8ml/ltr |
| T5 | 70 DAT | Shree Briddhi | 8ml/ltr |
| T6 | 85 DAT | Shree Briddhi | 8ml/ltr |
| C1 | - | - | - |
| C2 | - | - | - |

### Result and Discussion

#### Effect of treatments on growth of rice

The crop yield of rice (*Oryza sativa*) var. Pratikhaya is influenced by the application of humic acid based biostimulants ( NOP Sufalan and NOP Shree Briddhi). It has been observed from the above result that the number of mature grain is more in experimental plot than control.

**Table 2: Effect of biostimulants on growth parameter**

| For test | | | | | For control | | | |
|---|---|---|---|---|---|---|---|---|
| Sl no. | No. of tiller | Panicle per tiller | No. of grains per panicle | | No. of tiller | Panicle per tiller | No. of grainsper panicle | |
| | | | Mature | Immature | | | Mature | Immature |
| 1. | 1 | 12 | 193 | 4 | 1 | 18 | 280 | 31 |
| 2. | 1 | 17 | 265 | 8 | 1 | 17 | 160 | 130 |
| 3. | 1 | 14 | 220 | 3 | 1 | 16 | 17 | 260 |
| 4. | 1 | 11 | 197 | 7 | 1 | 17 | 195 | 45 |
| 5. | 1 | 16 | 280 | 9 | 1 | 16 | 222 | 43 |
| 6. | 1 | 13 | 198 | 8 | 1 | 18 | 43 | 209 |
| 7. | 1 | 12 | 190 | 4 | 1 | 15 | 96 | 33 |
| 8. | 1 | 15 | 200 | 6 | 1 | 18 | 224 | 17 |
| 9. | 1 | 16 | 240 | 5 | 1 | 17 | 176 | 23 |
| 10. | 1 | 14 | 225 | 6 | 1 | 16 | 157 | 49 |
| | | AVG- 14 | AVG -221 | AVG -6 | | AVG -17 | AVG -157 | AVG -84 |

## Conclusion

The study concluded that the foliar application of Sufalan and Shree Briddhiat tiller and panicle initiation stage could be recommended for cultivation of rice due to maximum yield in kharif season in new alluvial zone at Fulia seed farm, West Bengal.

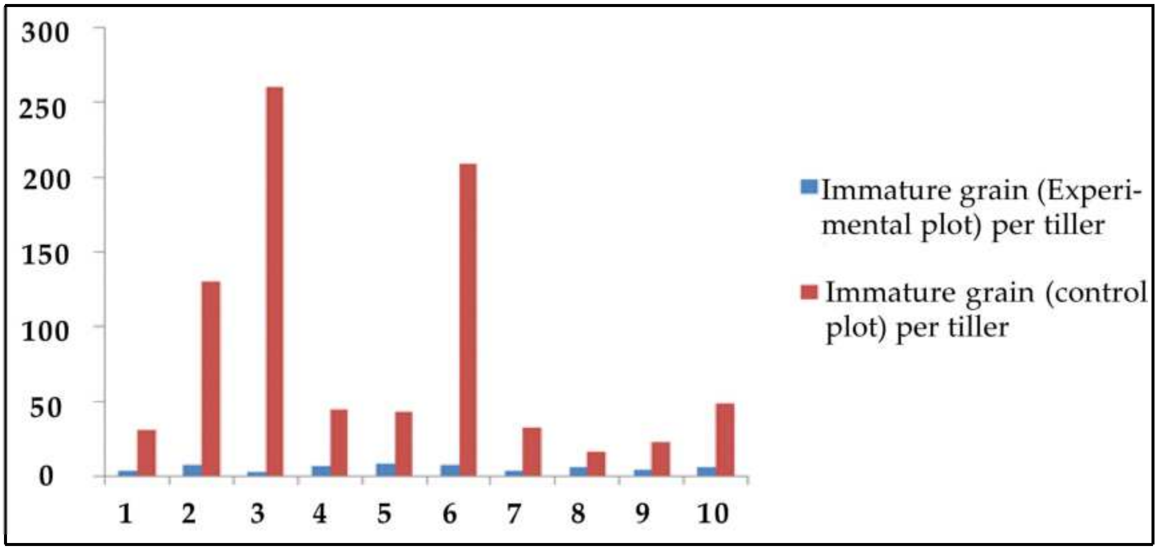


**Fig 1: Comparison of immature grain per tiller between experimental plot and control plot**

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# A Review on the Impact of Food Waste on Global Food Security

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## Introduction

Annually, 1.3 billion tons of edible food are wasted globally, about one-third of all food produced. High-income countries discard food fit for consumption, while low-income countries face losses mainly at the supply chain's start. UN and FAO research show that 56% of food loss and waste occurs in developed countries and 44% in developing countries. Avoidable losses occur when edible food is left unused, while unavoidable losses include items like fish bones. Reducing food waste should focus on avoidable losses throughout the supply chain. "Waste" refers to materials discarded after use, marking the end of their intended lifespan. Two key concepts are “food losses” and “food waste.” Food losses reduce the mass or nutritional quality of food intended for human consumption due to inefficiencies in the supply chain. In contrast, food waste consists of food that is fit for consumption but discarded because it has expired or spoiled.

**Principles of Food Waste Management**

**4Rs: Refuse, Reduce, Reuse & Recycle**

**Refuse:** The best way to manage waste is to refuse unnecessary items.

**Reduce:** Reducing trash is vital for waste prevention. Efficient cleaning, donating items and composting can help.

**Reuse:** "Reuse" means using products again before they become waste, without altering them.

**Recycle:** Recycling turns sorted waste materials into new products through a process that includes collecting recyclables, producing raw materials and manufacturing items.

**Prevention of Food Waste**

This prevention applies to all types of edible food, with land spreading being a viable option, though less beneficial than composting. Food is a valuable resource; it should not be wasted. Utilizing food waste to create valuable products is essential for addressing food loss and should always be considered before land filling or incineration (Khedkar and Singh, 2018).

**Methods for preventing food waste**

The best way to prevent food loss is

redistribution for human consumption. Food charities and food banks are good examples of this method. The most sustainable way to manage food waste is through animal feeding. Foods unfit for humans but suitable for animals like cows, goats and sheep should be assessed before use. Quantifying food waste is crucial for identifying its sources and types, enabling targeted preventive measures. By characterizing food waste, standardized protocols can be developed and applied throughout the food supply chain to create management systems that address food waste and loss (Beretta *et al.*, 2013). Effective communication strategies are essential for addressing changes in consumption patterns and social behavior. As food choices and types evolve, so does the waste produced, necessitating updates to prevention and management techniques. While food waste decreases as home cooking declines, packaging waste increases (Tara Slade 2016). Good manufacturing practices and dissemination of best practices and their reporting prevent food waste. According to the Indian Constitution, both state governments and urban local bodies (ULBs) are tasked with the management of solid waste. This responsibility is governed by the Municipal Solid Waste Management and Handling Rules of 2016. Under these rules, ULBs are designated as the authorities responsible for managing municipal solid waste within their respective areas and are mandated to establish the necessary infrastructure for effective implementation.

**Food Waste Treatment Technologies**

**Anaerobic Digestion (AD):** Anaerobic digestion (AD) is a process in which organic matter is decomposed by bacteria in an oxygen-free environment. Notably, anaerobic digestion recovers 60% more energy than direct combustion (Valorgas 2014).

**Composting:** Composting is a natural process that decomposes organic matter with the help of microorganisms and small invertebrates under controlled conditions. This generates heat, sometimes reaching up to 70ºC, which speeds up biodegradation and fermentation.

**Liquefaction:** Liquefaction is the process of converting food waste into liquid effluent through methods like mechanical, biological or hydrothermal liquefaction. The effluent can be discharged into household or municipal wastewater systems.

**Rendering:** Rendering transforms waste animal tissue and by-products into usable materials like high-quality fat and protein. Wet rendering separates fat by boiling in water, while dry rendering dehydrates to release fat. This process yields fat and valuable protein meal, suitable for animal feed.

**Thermal Treatment Can Be Used for Energy Recovery:** Thermal treatments with energy recovery, including gasification, pyrolysis and incineration are the only options for treating packaged food waste (non-biodegradable packaging) unless the food is still edible and can be redistributed. These methods can also be applied to mixed food waste.

**Water Footprint**

The disposal of food waste negatively affects both water sources, while overuse of fertilizers and pesticides diminishes water quality. Additionally, leachate from dumpsites and landfills contaminates groundwater and surface water. Untreated wastewater from food processing industries also contributes to pollution.

**Nutrient Loss of Agriculture Land**

Changes in agricultural practices have depleted soil nutrients. As the population grows, the amount of available agricultural land remains the same, leading to increased food demand and reliance on synthetic fertilizers. Urbanization has also increased food and waste production, which often does not return to farmland (UN, 2014).

**Hygiene and Sanitation**

Globally, about 50% of food waste is sent to landfills, with 13% to 33% openly dumped in lower and middle-income countries (The World Bank 2012). These sites pose health risks to nearby populati-ons, as organic waste can breed communic-able diseases and attract pests like mosquitoes and flies (ISWA 2015). Using technologies like anaerobic digestion to treat food waste can reduce disease spread and foul odors while promoting sanitation and hygiene.

**Ecological Impacts**

To meet the needs of a growing global population, ecological changes often increase food production, leading to deforestation and a loss of biodiversity. This loss can impact eating habits and contribute to lifestyle-related diseases. Global indicat-ors, such as soil quality and biodiversity loss are vital for assessing food production's effects. Segregating food waste enhances measur-ement and policymaking. Efficient collection and management systems are essential to prevent food waste from landfills.

**Economic Impacts**

Nearly one-third of food produced annually goes uneaten, costing the global economy over $940 billion and contributi-ng about 8% of greenhouse gas emissions. The overall economic, environmental and social costs of food waste amount to approximately $2.6 trillion, including waste management and landfill maintenance expenses. Additionally, food waste exacerb-ates financial crises, driving up food prices and healthcare costs related to shortages and diseases.

**Conclusion**

Food waste in the supply chain is a multifaceted issue that affects economics, agriculture and food security. Effective waste management is vital for environmen-tal conservation and human health. Tackling food waste requires sustainable strategies and cooperation among all stakeholders. Employing eco-friendly technologies can help prevent and reduce waste. When waste does occur, prioritizing technologies that minimize environmental impact and convert waste into energy is essential. Additionally, raising consumer awareness and education is crucial. All stakeholders must adopt sustainable, eco-friendly practices to address the global food waste problem effectively.

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# Chitosan as a Natural Enhancer for Improving Flower Production and Post-Harvest Quality

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## Introduction

Chitosan is a naturally occurring compound, which is commercially produced from seafood shells. It has been utilized in the induction of the defence system in plants against fungi, bacteria, virus and other abiotic stresses. In addition to that, chitosan effectively improves the physiological properties of plants and also enhances the growth, vase life and corm production of flower crops. It is also used as a growth stimulator. Moreover, chitosan treatment regulates several genes in plants, particularly the activation of plant defence signaling pathways (Sharif *et. al.*, 2018).

Now a days we are using chemicals for increasing plant growth, early, more and high yield. Also chemicals used for controlling diseases and pests. Using of chemicals in large quantities leads to environmental and ground water pollution. This cause harms full effect to human health and death of marine organisms. Chitosan is derived from chitin, a polysaccharide found in exoskeleton of shellfish such as shrimp, lobster or crabs and cell wall of fungi Poly (1,4) -2-amino-2-deoxy-β-D glucose, is a deacetylation product of chitin and it is available abundant in nature after cellulose.

### History of Chitosan

- 1811 Chitin was first discovered by Professor Henri Braconnot, who isolated it from mushrooms and name it "Fungine"
- 1823 Antoine Odier found chitin while studying beetle cuticles and named "chitin"
- 1859 Rought discovered chitosan, a derivative of chitin

• 1920s Production of chitin fibers from different solvent systems

• 1950s The structure of chitin and chitosan was identified by X-ray diffraction, infrared spectra and enzymatic analysis

• 1970s "Re-discovery" of the interest in chitin and chitosan

• 1977 1st international conference on chitin/chitosan

**Mile stone of chitosan production in India**

• The Central Institute of Fisheries Technology, Kerala, India initiated research on chitin and chitosan

• In 1978, Madhavan and Nair were first report that, dry prawn waste and dry squilla contained 23% and 15% chitin, respectively

• In 1986, Madhavan *et. al.*, reported that the chitinous solid waste fraction of the average Indian landing of shellfish ranged from 60,000 to 80,000 tons (Sharif *et. al.*, 2018)

• Chitin and chitosan are now produced commercially in India, Poland, Japan, United States, Norway and Australia

**Properties of Chitosan**

• **Linear polyamine:** It is simple polymer, where carbon carbon bonds are exist in single line

**Reactive amino groups:** Amino groups are attached to single carbon atom. So highly reactive

• **Reactive hydroxyl groups available:** It is also having hudroxyl group

• **Chelates many transitional metal ions:** Chitosan form the bond with heavy metal and help more their removal. So chitosan is used in pharmaceutical industry and also used for water purification

• It is non-toxic, biodegradable and biocompatible

• Chitosan has strong antimicrobial and antifungal activities that could effectively control fruit decay

• Chitosan is highly hydrophobic and ability to form films

**Sources of chitosan**

Chitosan is commonly found as a supporting material in various aquatic organisms, including the shells of shrimps and crabs, as well as the bone plates of squids and cuttlefish. It is also present in some insects, such as mosquitoes, cockroac-hes, honeybees, silkworms, *Drosophila melanogaster*, *Extatosoma tiaratum* and *Sipyloidea sipylus*. Additionally, it occurs in terrestrial crustaceans like *Armadillidium vulgare* and *Porcellio scaber.* In the fungal kingdom, chitosan is found in certain mushrooms, such as *Agaricus bisporus*, *Auricularia auricula-judae*, *Lentinula edodes*, *Trametes versicolor*, *Armillaria mellea*, *Pleurotus ostreatus*, *Pleurotus sajor-caju* and *Pleurotus eryngii*. Furthermore, it is present in microorganisms, including yeast, fungi and diatoms.

**Process of production of chitosan**

**1. Demineralization:** It has been carried out with three different concentration of HCl (4%, 3%, 2%) at ambient temperature (28±2°C) with a solid to solvent ratio 1:5 (w/v) for 16 hours. The residue is washed and soaked in tap water until it reaches neutral pH

**2. Deproteinization:** The residue was washed and soaked in water until neutral pH. Then purified chitin was dried until it become crispy. Chitin flakes was grounded to small particle to facilitate deacetylation

**3. Deacetylation:** Removal of acetyl groups from chitin was done using 4 different concentration of NaOH (30%, 40%, 50%, 60%) at 65°C temperature with a solid to solvent ratio 1:10 (w/v) for 20 hours. The residue was washed until neutral pH with tap water. The resulting chitosan was then dried at cabinet dryer for 4 hours at 65±5°C

**Application of chitosan in plants**

• **Chitosan acts as an elicitor:** Chitosan acts as an elicitor by stimulating the plant's innate immune system. This leads to the activation of defensive genes that help the plant resist pathogens like fungi, bacteria and viruses. This process involves the synthesis of secondary metabolites, such as phytoalexins, which have antimicrobial properties.

- **Chitosan is involved in narrowing the stomatal apertures:** When chitosan is applied to plants, it can trigger defense responses that lead to the closure of stomata. This response is part of the plant's effort to conserve water and prevent the entry of pathogens. Closing stomata limits water loss during times of stress and helps to reduce the chances of pathogen infiltration through the stomatal pores.
- **It is used in seed coating:** Chitosan has natural antifungal, antibacterial and antiviral activities, which help protect seeds from microbial infections during germination. By coating the seed with chitosan, it forms a protective barrier that reduces the chances of seed-borne diseases, such as fungal infections (e.g., *Fusarium, Rhizoctonia and Pythium*) that can inhibit germination or cause seedling death.
- **Chitosan increases chlorophyll content in leaves:** Chitosan can enhance the photosynthetic efficiency of plants. Chlorophyll plays a central role in photos-ynthesis by absorbing light energy and converting it into a form that plants can use for producing sugars and other essential compounds. When chitosan is applied, it helps stimulate the production of chlorophyll, which in turn boosts the plant's overall photosynthetic capacity. This leads to increased energy production and enhanced growth.
- **Fruit and vegetable coating:** Chitosan is an effective, eco-friendly solution for coating fruits and vegetables due to its strong antimicrobial and antifungal properties. By forming a protective layer on the surface of fresh produce, chitosan helps reduce spoilage caused by bacteria and fungi, extend shelf life, maintain quality and preserve nutrients. Its natural, biodegradable nature makes it a sustainable alternative to synthetic preservatives, making it an increasingly popular choice in the food industry for post-harvest treatment.
- **Fertilizer:** Chitosan can also act as a slow-release fertilizer, providing a sustained supply of nutrients over time. This helps prevent nutrient leaching (especially nitrogen) and reduces the need for frequent fertilizer applications. The slow release of nutrients ensures that plants receive a steady, adequate supply without the risk of nutrient overload.
- **Biopesticide and fungicide:** Chitosan is a promising natural alternative to synthetic pesticides and fungicides, with the advantage of being safe for the environment and non-toxic to humans. Its ability to repel pests, inhibit fungal growth, and boost plant immunity makes it a valuable tool in sustainable agriculture.

### Use of chitosan in flowers

**Used to break the dormancy of corm:** Garcia *et. al.*, (2009) studied the response of gladiolus (*Gladiolus* spp.) plants after exposing corms to chitosan and hot water treatments. Among the four treatments, corms dipped in Biorend at 1.5% and hot water at 50°C accelerated their emergence for about 1 to 7 days, the number of flowers increased by two, extended the storage life for 1 to 3 days and increased the number of cormlets to 9.3.

**Increase the vase life of flowers:** Mehraj *et. al.*, (2016) studied the effects of floral preservative solutions for vase life evaluation of gerbera. They revealed that among nine treatments, Yellow gerbera showed the maximum petals water content (52.4%)

when placed in salicylic acid + chitosan (100 ppm). It also provided eight days more vase life compared to the control. Whereas maximum petals water content was recorded in citric acid + chitosan (100 ppm) in Magenta (56.3%) and Orange (63.0%) and 6.9 days more vase life than control.

**Used as a media in tissue culture:** Nge *et. al.,* (2017) studied the chitosan as a growth stimulator in orchid tissue culture. They found that, fungal chitosan and shrimp oligomer chitosan applied at 15 and 20 ppm were most effective on protocorm propagation in liquid and agar media.

**Chitosan is used for disease control:** Wojdyla (2018) studied the chitosan in the control of rose powdery mildew and downey mildew. They found that chitosan reduced development of powdery mildew from 43.5% to 77% at concentration of 0.05%. Downey mildew was reduced from 55% to 74% at the concentration of 0.0625%.

**Used as a fertilizer:** Chitosan at 20 mg/L along with foliar fertilizer NPK (20:20:20) increased inflorescence length and weight compared to the other chitosan treatments. These results showed that chitosan has potential to improve quality of *Curcuma 'Laddawan'* (Tamala *et al*., 2012).

## Drawback of chitosan usage

While Chitosan has promising benefits as an eco-friendly and natural alternative to synthetic pesticides, it also has limitations, such as effectiveness issues, cost and environmental factors. Careful consideration is needed when using it, especially for large-scale farming operations or in areas with specific pest and disease challenges.

## Conclusion

Chitosan application showed that each crop responds in a different way based on the chemical composition of chitosan, timing and rate of application. It stimulates plant growth, increased the yield and vase life of flowers and activation of secondary metabolites. Chitosan, as a unique abundant biopolymer, has a promising future for improving quality and production of flowers.

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# Climate Change and Its Impact on Fruit Production: A Growing Concern for Indian Horticulture

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## Introduction

The effect of climate change is no longer confined to distant predictions; they are a present reality, impacting every aspect of agriculture, especially fruit production. With rising temperatures, erratic rainfall patterns and increased incidences of extreme weather events, the horticultural landscape in India is undergoing rapid transformations. According to the IPCC, the temperature in the Indian subcontinent would rise by 0.5 to 1.2°C by 2020, 0.88 to 3.16°C by 2050 and 1.56 to 5.44°C by 2080, depending on future progress. The primary factors of climate change are abnormal rainfall patterns and an unpredictable high or low temperature regime, both of which have comprehensive consequences for agriculture in general and horticulture in particular. Understanding these changes and implementing effective mitigation strategies is crucial for securing the future of India's fruit industry.

### Effect of Climate Change on Fruit Growth

Global warming has led to significant shifts in temperature and weather patterns, which directly affect fruit growth. Most fruit crops have specific temperature requirements during their vegetative and reproductive stages. For instance, apple, peach and pear rely on cold winters to break dormancy and initiate flowering. In regions experiencing warmer winters, these chilling requirements are not met, resulting in poor flowering, irregular fruiting and reduced yields.

Similarly, high temperatures during the flowering stage can cause flower drop and hamper pollination. This is particularly detrimental to crops such as mango, lychee and citrus fruits, where successful pollination is critical for a good fruit set.

### Impact on Harvest Cycles

Changing climate patterns are also altering the timing of harvesting. Unpredictable weather-from untimely rains to prolonged dry spells-can disrupt normal growth cycles. For example, monsoon-dependent fruit crops like mango and guava are highly vulnerable to untimely rains, leading to premature fruit drop or delayed harvests. This directly affects the marketability and profitability of fruit production, leaving farmers in a precarious financial situation.

Moreover, fruit ripening times are also shifting. Grapes, a major fruit crop in India, have shown early ripening due to rising temperatures. This disrupts the supply chain and poses challenges for storage and transportation. The changing harvest cycles also mean farmers must adjust their cultural practices, including irrigation, fertilization and pest management.

**Quality Concerns: Taste and Nutritional Value**

One of the less-discussed but critical effects of climate change is its impact on fruit quality. Rising $CO_2$ levels, combined with increased temperatures, have been found to alter the sugar-acid balance in fruits, thereby affecting their taste. Fruits like strawberries and tomatoes have shown a decline in flavour intensity under high-temperature conditions. Similarly, a reduction in vitamin C and other antioxidants has been observed in several fruit crops due to climate-induced stress.

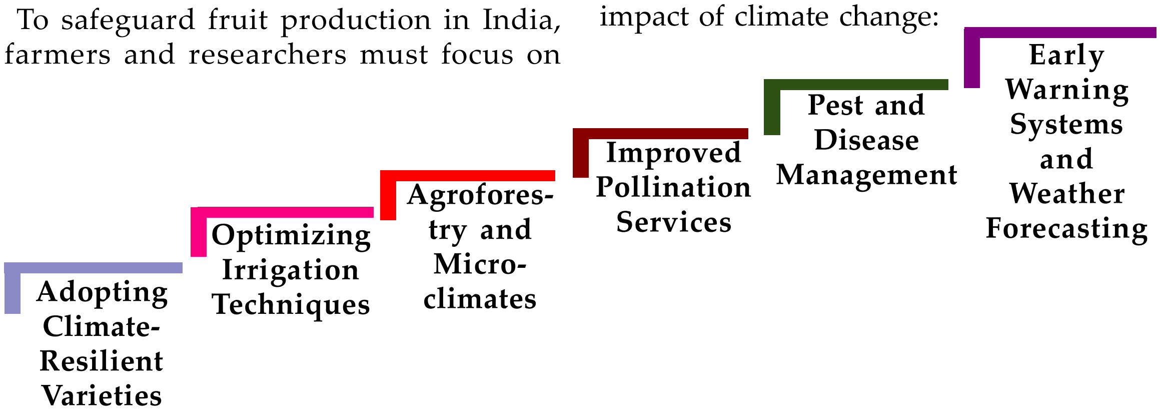
Moreover, fruits exposed to excessive heat during development tend to have a lower shelf life, poor texture and a higher susceptibility to diseases. Sunburn damage, cracking and reduced skin firmness are common problems encountered by fruit growers in hot climates.

**Table 1: Climate change impacts on fruit crops in India, with expected yield reductions, quality changes and pests/diseases.**

| Fruit | Climate Impact | Expected Effect on Yield | Quality Impact | Key Pests/Diseases |
|---|---|---|---|---|
| Mango | Higher temperatures during flowering | 10-15% reduction | Smaller fruits, sunburn | Mango hoppers, fruit flies |
| Apple | Reduced chilling hours | Up to 20% reduction | Poor fruit set, smaller fruits | Codling moth |
| Grapes | Premature ripening due to heat | Size reduction | Lower sugar-acid balance | Powdery mildew, downy mildew |
| Citrus | Drought and erratic rainfall | Size reduction | Lower juice content, sugar drop | Citrus psyllid (spreads greening) |

**Mitigation Strategies: Protecting Fruit Production from Climate Change**

To safeguard fruit production in India, farmers and researchers must focus on adopting climate-resilient practices. Here are some key strategies to mitigate the impact of climate change:




**I. Adopting Climate-Resilient Varieties:** Breeding and promoting fruit varieties that are tolerant to heat, drought and salinity is critical.

**II. Optimizing Irrigation Techniques:** Efficient irrigation practices like drip irrigation and mulching can help conserve water and ensure adequate moisture for fruit crops, especially during prolonged dry spells. Farmers should be encouraged to adopt

**Table 2. Resistant rootstocks and varieties of fruit crops against biotic and abiotic stresses**

| Crops | Varieties/ rootstocks |
|---|---|
| **Mango** | 13-1, Kurakkan, Nileshwar dwarf, Bappakai |
| **Guava** | *P. molle × P. guajava, P. cujavillis* |
| **Pomegranate** | Ganesh, Dholka, Jalore Seedless, Mridula, Phule Arakta, Bhagawa, Ruby, Amalidana, G-137, Jyoti, Basin Seedless |
| **Grape** | Dogridge, 110R, SO-4 |
| **Sapota** | Khirni |
| **Ber** | Gola, Seb, Umran, Banarasi Karaka, Kaithali, Mundia, Goma Kirti, Thar Bhubharaj, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel.-1 & 2, ZG3, Sanaur |
| **Bael** | Kagzi, Mirzapur Seedling, Etawah, Gonda, Ayodhya, NB-5, NB-9, Pant Aparna, Pant Urvashi, Pant Shivani, Pant Sujata, CISH Bael-1 & CISH Bael-2 |
| **Aonla** | Banarasi, Chakaya, Francis, NA-6, NA-7, NA-10, Kanchan, Krishna, Anand-1, Anand-2, Lakshmi-52, BSR-1, Chakaiya, BSR-1 |
| **Custard apple** | Balanagar, Mammoth, Island Gem, APK (Ca) 1, Arka Sahan |
| **Fig** | Poona Fig, Dinkar, Dianna, Conadria, Excel |

rainwater harvesting techniques to store and use water effectively during lean periods.

**III. Agroforestry and Microclimates:** Establishing a microclimate by planting windbreaks and shade trees around fruit orchards can help moderate the impacts of strong winds and high temperatures. Agroforestry practices boost biodiversity, prevent soil erosion, enhance soil quality and aid in water conservation.

**iv. Improved Pollination Services:** The decline in pollinator populations due to climate change has affected fruit production, as pollinators play a crucial role in fruit set. Promoting managed pollination services, such as the use of honeybee colonies in orchards, can help offset the loss of natural pollinators and enhance fruit yield

**V. Pest and Disease Management:** Warmer temperature and changing rainfall pattern are increasing the prevalence of pests and diseases in fruit crops. Integrated Pest Management (IPM) techniques, coupled with biological control methods, should be promoted to reduce the reliance on chemical pesticides and protect crop health.

**VI. Early Warning Systems and Weather Forecasting:** Accurate weather forecasts and early warning systems enable fruit growers to better organize their agricultural practices. By predicting unfavourable weather, farmers can adapt irrigation timing, use protective sprays and efficiently plan labour and harvest tasks.

## Conclusion

Climate change poses considerable obstacles for fruit production in India, but with strategic action, these challenges can drive innovative solutions. Collaboration among farmers, researchers and policymakers is essential to create climate-resilient horticultural practices that not only sustain yields but also enhance the livelihoods of millions of farmers. The future of India's fruit industry relies on our capacity to adapt to these evolving conditions while preserving the quality, variety and sustainability of fruit crops. Through implementing these approaches and prioritizing research and technology, India can remain a top producer of premium fruits in an increasingly climate-impacted world.

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# Sapota: Traditional Uses, Nutritional and Health Importance

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## Introduction

Sapota, also known as sapodilla (*Manilkara achras* (Mill) Forsberg), originates from Tropical America (Mexico) and is a significant tropical fruit crop in India. Belonging to the Sapotaceae or Naseberry family within the order Ebenales, this fruit is recognized by various names such as chickoo, sapota plum and sapodilla. Its diploid chromosome number is 2n=2x=26. It boasts small bell-like flowers measuring about 8-12 mm in diameter, which are inconspicuous and brown in color, arranged in clusters on slender stalks emerging from the leaf axils. With several flowering cycles occurring throughout the year, the sapodilla tree produces round or oval fruits with thin skin, characterized by a rusty brown outer surface. The ripe fruits exhibit a pale yellow-brown hue and a grainy texture, while their sweetness, attributed to sugars like glucose, fructose and sucrose, renders them highly flavorful. Each fruit typically contains 3-12 seeds, predominantly around 5, loosely attached to the fruit's center.

**Mature fruit of Sapota**

The establishment of the first sapota plantation in 1898 in Gholvad village, Maharashtra, marked the beginning of its spread across southern and western India. Over time, its cultivation expanded to various tropical regions, predominantly in

Central and South America. However, it is now predominantly grown in India, Mexico, Philippines, Vietnam, Malaysia, Indonesia, Thailand, Sri Lanka and Bangladesh (Lim, 2013). India stands as the leading global producer of sapota, with an extensive cultivation area exceeding 73 thousand hectares and an annual production reaching around 889 thousand tonnes (https://agriwelfare.gov.in/2023-24). Gujarat holds the top position in sapota production within India, yielding 270.99 thousand tonnes, followed by Andhra Pradesh with 262.06 thousand tonnes and Maharashtra with 89.09 thousand tonnes (https://agriwelfare.gov.in/2023-24). Notably, sapota thrives in states like Gujarat, Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu and West Bengal, ensuring year-round fruit production. In contrast, regions such as Punjab and Haryana in subtropical climates yield fruits only once a year. The optimal temperature range for successful cultivation falls between 11 to 34 degrees Celsius. Elevated temperatures, such as 41 degrees Celsius, result in drying of the stigmatic surface. An annual rainfall ranging from 125 to 250 centimeters is considered ideal. Fruit set remains unaffected by precipitation or overcast conditions throughout the year. It thrives in a variety of soil types, with deep sandy loams, alluvial soils or medium black soils being particularly suitable. High lime content in the soil is intolerable for this plant. It flourishes in soils with a pH range of 6 to 8.

### Traditional uses of sapota

**Fresh Fruit:** Mature sapota fruits are commonly enjoyed by slicing them in half, then scooping out the flesh with a spoon. The flesh is a delightful addition to salads or fruit medleys. For a delectable treat, the ripe fruit can be pressed to extract its juices, mixed with orange juice and served with a dollop of whipped cream.

**Value added products:** Reformulated variations of sapota, including squash, jam, slices, butter, cheese, candy, powder, biscuits, ice cream, shrikhand, juice, sweet chutney, dried sapota flakes, milkshake, Osmo-dehydrated slices, nectar, lassi, chocolate, chewing gum, fruity toothpaste, ready-to-drink beverages, spray-dried powder, carbonated drinks and fermented wine beverages, are considered value-added products.

**Cooking:** The flesh of sapota can be utilized as an ingredient in baking by incorporating it into an egg custard mix before placing it in the oven. Typically, sapota is not subjected to cooking or preservation methods, although it may occasionally be fried. The process of cooking the fruit results in a transformation of its flesh, turning it into a reddish hue.

**Cosmetic value:** Sapota, renowned for its nutrient richness, serves as an herbal solution for skin infections and beauty enhancement. The abundance of Vitamins E, A and C in *Achras zapota* fruit promotes skin health by providing moisturization. Its antioxidant properties, including ascorbic acid, polyphenols and flavonoids, aid in wrinkle reduction. Additionally, sapota seed oil is effective in addressing hair fall caused by seborrheic dermatitis.

### Nutritive value

Sapota, a fruit rich in nutrients, boasts a diverse array of beneficial elements including dietary fiber, fructose, glucose, sucrose, vitamins, minerals, phytochemicals, fatty acids and polyamines. The reduction in astringency observed during the fruit's maturation process is attributed to alterations in its polymer structure, interactions among various constituents like sugars and a decline in polyphenol concentration as the fruit enlarges.

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**Table. Nutritional components of sapota (*Manilkara zapota*) fruit per 100 g edible portion.**

| Constituent | Approximate value | Constituent | Approximate value |
|---|---|---|---|
| Water | 78.00 g | Pantothenic acid | 0.2528 mg |
| Protein | 0.44 g | Vitamin B-6 | 0.037 mg |
| Total fat | 1.10 g | Folate | 14 μg |
| Ash | 0.50 g | Vitamin A | 60 IU |
| Total dietary fiber | 5.3 g | Vitamin C | 14.7 mg |
| Carbohydrate | 19.96 g | Riboflavin | 0.020 mg |
| Niacin | 0.200 mg | Oleic acid | 0.521 g |
| Calcium | 21 mg | Linoleic acid | 0.011 g |
| Magnesium | 12 mg | Tryptophan | 0.005 g |
| Phosphorus | 12 mg | Leucine | 0.024 g |
| Potassium | 193 mg | Lysine | 0.039 g |
| Sodium | 12 mg | Arginine | 0.017 g |
| Zinc | 0.10 mg | Aspartic acid | 0.032 g |
| Copper | 0.086 mg | Lutamic acid | 0.038 g |
| Iron | 0.80 mg | Proline | 0.036 g |
| Selenium | 0.6 μg | Lycopene | 41.93 (μg 100 $g^{-1}$ DW) |
| Stearic acid | 0.094 g | Total phenolic | 13.5(mg GAE 100 $g^{-1}$) |
| Palmitic acid | 0.1 g | | |

**Health benefits/ medicinal properties of Sapota**

Sapota is known for its anti-inflammatory properties and high dietary fiber content, making it a popular choice in India where it has been traditionally used for its antibacterial and antiviral benefits. Its rich nutrient profile contributes to overall health, despite being calorie-dense. Notably, various parts of the sapodilla plant, not just the fruit, have been utilized for their medicinal properties, including treating colds and coughs due to their antidiarrheal, diuretic, antihyperglycemic, antibiotic and hypercholesterolemic effects. Across different cultures, sapota fruit has served as a traditional remedy, with the immature fruit, in particular, being employed to address diarrhea owing to its high tannin content. Additionally, infusions made from young sapota fruit have been documented to alleviate lung complaints.

**Antibacterial activity:** According to research, the significant antibacterial activity was observed in acetone extracts from *Manilkara zapota* and *Tamarindus indica*, as well as in the methanolic extract of *Tamarindus indica*, when compared to standard drugs such as streptomycin and ofloxacin.

**Anti viral and anti-fungal properties:** Because of its polyphenolic antioxidants, sapota possesses various anti-viral, anti-parasitic and antibacterial properties. These antioxidants inhibit bacteria from entering the human body. Additionally, Vitamin C eliminates harmful free radicals, while potassium, iron, folate, niacin and pantothenic acid support the optimal functioning of the digestive system.

**Relieves stress:** Sapota, abundant in Vitamin C with a content of 14.7 mg, serves as a valuable resource for bolstering the immune system, particularly in instances of weakened immunity induced by stress. Given the prevalent issue of stress affecting health, ensuring sufficient intake of

Vitamin C through sources like sapota can significantly enhance overall well-being and alleviate its adverse effects.

**Helps in digestion:** Fiber plays a crucial role in enhancing digestive health. Insoluble fiber aids in the smooth passage of stool and promotes bulk within the digestive system, helping to prevent ailments such as colon cancer, diverticulitis and inflammatory bowel diseases.

**Antidiarrhoeal activity:** The extract's ability to combat diarrhea might stem from its capacity to enhance the absorption of electrolytes and water in the gastrointestinal tract or from its inhibition of prostaglandin biosynthesis. The presence of flavonoids and saponins could contribute to its antidiarrheal effects.

**Benefits during pregnancy:** Containing a rich dose of carbohydrates and essential nutrients, sapota is highly advantageous for expectant and breastfeeding mothers. It aids in alleviating weakness and mitigating common pregnancy symptoms like nausea and dizziness.

**Aids in weight loss:** Sapota fruit contributes to weight loss and obesity prevention by indirectly regulating the secretion of gastric enzymes, thus modulating metabolism.

**Hepatoprotective effect:** The hepatoprotective function of *Manilkara zapota* relies on its potent antioxidant properties attributed to the presence of flavonoids, carotenoids and ascorbic acid found in sapota.

**Healthy bones:** Increased levels of calcium, phosphorus and iron are necessary for improving the resilience of bones. With its abundance of calcium, iron and phosphorus, sapota fruit significantly aids in fortifying and reinforcing bones. Copper is indispensable for bone growth, connective tissue development and muscle health.

**Anticancer activity:** Phenolic compounds found in sapota fruit exhibit various anticancer properties. For instance, methyl 4-O-galloylchlorogenate extracted from sapota fruit demonstrates cytotoxic effects in human colon cancer cell lines HCT-116 and SW-480, with IC50 values of 190 μM and 160 μM, respectively.

**Controls blood pressure:** The presence of magnesium in sapota contributes to the maintenance of healthy blood vessels, while its potassium content helps regulate blood pressure and circulation. Additionally, sapota's abundance of iron makes it beneficial for treating anemia.

**Good for the eyes:** Sapota is rich in Vitamin A, which plays a crucial role in enhancing vision, particularly as one age. Therefore, incorporating sapota fruit into your diet can contribute to maintaining and improving eye health.

**Kidney stones:** The pulverized seeds of this fruit function as a diuretic, aiding in the elimination of bladder and kidney stones. Additionally, they offer defense against kidney ailments.

**As a detoxifying agent:** Sapota functions as a diuretic, aiding in the elimination of waste materials from the body through increased urination. It effectively prevents oedema or water retention by regulating the body's water balance.

## Conclusion

Sapota, a delectable fruit, boasts numerous medicinal and cosmetic benefits across all parts of the plant. Its medicinal properties stem from chemical compounds including polyphenols, ascorbic acid and glycoside saponins. Renowned for its nutritional richness, sapota aids in managing various ailments such as inflammation, pain and diarrhea. Furthermore, its application extends to cosmetics. The creation of value-added products such as juice, vinegar, jam and wine serves to enhance the economic significance of sapota.

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# Innovations in Biofortification: A Key to Achieve Nutritional Security

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## Introduction

Biofortification is the process of increasing the essential nutrient content in food by means of altering the existing package and practices of the crop production and through genetic intervention.The term "biofortification" is derived from the Greek word *bios*, meaning "life," and the Latin word *fortificare*, meaning "to make strong", thus conveying the concept of "strengthening life". The concept of biofortification can be traced back to the period of the Green Revolution (1966-1985). However, the specific term "biofortification" was first introduced by Steve Beebe, a bean researcher at the International Center for Tropical Agriculture (CIAT), in the early 2001. There are two types of biofortifications such as agronomic and genetic biofortification. Agronomic and genetic biofortification are complementary to each other. Only by increasing the genetic potential or by optimizing the growth factors and availability of nutrient, ultimate potential cannot be achieved. There are primarily four methods of micronutrient intake in human system such as dietary diversity, food fortification, supplementation through medicine and biofortification. Among these methods, biofortification is the cheapest way to serve the nutritious food to a large population. United Nations and Government of India have emphasized the biofortification as the need of the hour. Therefore, for achieving the sustainability and for combating the malnutrition, agronomic and genetic biofortification both are indispensable.

### Significance of biofortification *via-a-vis* existing circumstances

**1. Population pressure and food security**

World population is increasing at alarming rate and it is projected to reach up to 8.89 billion and 9.75 billion by 2030 and 2050, respectively. India accounts for more than 17% of world population which is continuously increasing and it is the main constrains to achieve nutritional security after satisfying the food security. After green revolution, food production has been increased 6 times which makes India self-sufficient in food. However, owing to dilution effect and less attention on micronutrient and food quality, nutritional security has been arisen as a major concern. In India, hidden hunger for micronutrient deficiency is predominant for Zn, Fe, Ca, I. According to Harvest Plus-India report, 70% of children (< 5 years) and 35% of children (< 5 years) were detected as Fe and Zn deficient, respectively. Zn deficiency causes impaired immunity, skin disease (Figure 1) and frequent infection and Fe deficiency is also manifested as fatigue, dizziness and anemia. These cause the biggest impediment to achieve UN Sustainable Development Goal-3 (Good health and wellbeing to ensure healthy lives for people).

**2. High yielding varieties and improper nutrient management**

Moreover, release of high yielding variety, main importance to the primary nutrient in fertilizer and depletion of soil organic carbon due to improper management practices led to the wide spread micronutrient (Zn, Fe, Mn, Cu, B) insufficiency in Indian soil and consequently inadequate accumulation of important micronutrient in grain is taking place. Although, per capita food grain availability in India is ~515 g $d^{-1}$, they are not nutritionally as reach as to full fill the recommended dietary allowance (Table 1).

**3. The cost of malnutrition**

In 2024, out of 127 countries, India's position is 105th in Global Hunger Index score (27.3) which indicates a worst condition in nutritional security. As a result, each year India losses about US$12 billion GDP due to malnutrition in large population.

Keeping these above facts in view, as the

**Figure 1. Symptoms of Zn deficiency in child**

**Table 1. Recommended dietary allowance for Indians (given by ICMR-NIN)**

| Sl. No | Nutrient | Recommended dietary allowance |
|---|---|---|
| 1. | Protein | 60-55 g $d^{-1}$ |
| 2. | Zn | 10-12 mg $d^{-1}$ |
| 3. | Fe | 17-21 mg $d^{-1}$ |
| 4. | Ca | 600 mg $d^{-1}$ |
| 5. | Mg | 31-34 mg $d^{-1}$ |
| 6. | Mo | 45 µg $d^{-1}$ |
| 7. | Cl | 1800-2300 mg $d^{-1}$ |
| 8. | Cu | 1.7 mg $d^{-1}$ |
| 9. | Se | 40 µg $d^{-1}$ |
| 10. | Mn | 4 mg$d^{-1}$ |

nutritious food is the bedrock of nation's development; the strategies of biofortification should be urgently adopted to increase the production of nutritious food and their availability to common people. The urgency of biofortification was also recognized in UN food system summit, 2021.

**Strategies of biofortification**

Agronomic biofortification is the modification of the existing technology of crop production while considering the disparity between demand and supply of the essential growth factor for exploring the ultimate potential of a crop in terms of nutrient accumulation in edible part. On the other hand, genetic biofortification is the improvement of the genetic potential of a crop towards accumulation of essential nutrients in edible part of the crop.

**1. Agronomic biofortification**

There are different methods of biofortification through agronomic intervention. Some important methods have been enlisted below.

**Conjoint application of macro and micro nutrient:** In many cases deficiency symptoms of micronutrients (Zn, Fe, Mn, Cu) are not manifested in most of the crops but concentration of those micronutrients in grain are substantially reduced, as a result, nutritional quality of food is deteriorated. Application of micronutrients could be done through fertilizer application in soil. Soil application of $ZnSO_4$ @25 kg $ha^{-1}$, $CuSO_4$ @ 10 kg $ha^{-1}$, $MnSO_4$ @ 10 kg $ha^{-1}$ and Borax @10 kg $ha^{-1}$ are the general recommendation of micronutrient containing fertilizer in most of the field crops. ZnO and $ZnSO_4$ coated urea can also be used as a Zn supplement. However, in wheat, application of $ZnSO_4$ coated urea resulted in higher Zn availability in soil and eventually Zn content in grain was significantly higher (Shivay *et al.*, 2016).

**Foliar application of micronutrient:** Most of the important micronutrients are immobile in plant; to overcome this problem micronutrients can be applied through foliar spray. Jalal *et al*. (2020) reported that foliar fertilization of 0.3% Zn and 1% Fe resulted in higher wheat yield and higher Zn and Fe content in grain. In another experiment combined foliar spray of 0.5% $ZnSO_4$ and 1% $FeSO_4$ significantly improved the maximum growth and quality attributes of wheat (Ramzan *et al.*, 2020).

**Seed treatment and microbial inoculation:** Seed priming with micronutrient solution improve the initial growth of the plant that maintain proper plant metabolism and enzymatic activity throughout the growing period. As a result, micronutrient partitioning in food grain get increased. Microbial inoculation through seed treatment (Kundu *et al.*, 2023) and root dipping could also be considered as promising alternative for higher nutrient availability and uptake. For instance, seed priming with a combination of zinc (Zn) and *Pseudomonas sp*. MN12 had found to be more cost-effective compared to other application methods for bread wheat biofortification (Rehman *et al.*, 2018). Additionally, priming wheat and barley seeds with 2 mg $L^{-1}$ of both Fe and Zn enhanced grain yield and tillering in bread wheat, demonstrated an alternative approach in fortification process of crop produce (Carvalho *et al.*, 2019).

**Nanotechnology in biofortification:** Nanotechnology has emerged as an effective tool for enhancing plant nutrition, facilitates the acquisition and storage of essential micronutrients in staple foods (Table 2). Hence, application of nano fertilizers at proper time and dose may potentially alleviate large-scale malnutrition and under nutrition through the food supply chain. Among various zinc (Zn) fertilization sources, nano zinc oxide (≤74 nm)- coated urea has been identified as the most efficient method in basmati rice biofortification with Zn, compared to additional dose of 5 kg Zn $ha^{-1}$ through ZnO along with urea (Baral *et al.*, 2023).

**Table 2. Effect of different nano fertilizers on produce quality**

| Crop | Type of nano fertilizer | Dose | Remarks | References |
|---|---|---|---|---|
| Wheat | $Fe_2O_3$-NPs (Particle size ~20 nm) | 50-500 mg $Fe_2O_3$ $kg^{-1}$ soil (pot experiment) | Cysteine, tyrosine and Fe content in grain were significantly increased. | Wang *et al.* (2019) |
| Common bean (*Phaseolus vulgaris*) | ZnO-NPs (~20 nm) | 10-40 ppm (Foliar spray) | Highest yield & grain Zn content were recorded with ZnO-NPs @ 30 ppm foliar spray. | Salama *et al.* (2019) |

**Other ways of agronomic biofortification:** There are different ways of agronomic intervention which change the soil physical, chemical and biological properties and indirectly alter the micronutrient availability in soil. For instance, green manuring and residue incorporation improve the soil biological health and decomposition of biomass leads to the production of organic acids which solubilize the immobile micronutrients and facilitate the uptake by plant (Pooniya *et al.*, 2012). Similarly, application of biochar and organic amendments result in higher soil cation exchange capacity and increase chelation by which micronutrient become accessible to plant.

**Figure 2 Golden Rice**

## 2. Genetic biofortification

There are two different methods of genetic biofortification i.e., conventional breeding and transgenic plant.Conventional breeding is the process of selectively crossing plants with desirable traits to produce offspring with those traits. It relies on natural genetic variation. Whereas, a transgenic plant is a genetically modified plant that has been altered by inserting foreign DNA from another species to introduce new traits. Through conventional breeding many varieties have been evolved (Table 3) and one of the most popular transgenic biofortified crops is golden rice (Figure 2) with a higher level of beta carotene (~35 $\mu g\ g^{-1}$) in endosperm.

**Table 3. Important biofortified verities for staple food crops**

| Crop | Variety | Significant character |
|---|---|---|
| Rice | CR Dhan-311 | ~10.2 %protein and 20ppm Zn |
| | DRR Dhan-45, 48, 49 | ~24 ppm Zn |
| Wheat | PBW-771, 757 | ~42 ppm Zn |
| | HD-3249, DBW-187 | ~42 ppm Fe |
| Maize | HHB-311 | ~83 ppm Fe |
| | Pusa VH-27 improved | ~5.49 ppm provitamin -A |

## Conclusion

Innovations in biofortification hold tremendous potential in addressing global nutritional insecurity by enhancing the micronutrient content of staple crops. This strategy offers a sustainable and cost-effective solution to combat malnutrition, especially in developing countries where access to diverse and nutritious foods is limited. Advances in genetic engineering, conventional breeding techniques and agronomic practices have paved the way for biofortified crops that can improve the health and well-being of vulnerable populations. However, successful implementation requires coordinated efforts involving farmers, policymakers, researchers and global organizations to ensure widespread adoption and equitable access. Ultimately, biofortification is a crucial tool for fighting against malnutrition, while contributing towards improved health outcomes and long-term food and nutritional security.

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# Integrated Pest Management of Insect Pests in Brinjal

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## Introduction

The eggplant, also known as brinjal (*Solanum melongena* Linn.), is a common and widely grown vegetable in the globe. It is also known as aubergine or guinea squash and is considered the "King of vegetables" since it is the most widely grown and important vegetable crop in the Solanaceae family. For low-income consumers and small-scale growers worldwide, it is a versatile and economically significant vegetable. On total acreage, it is the most popular vegetable in the nation and the top summer and winter vegetable. Asia accounts for 87% of global production and 90% of the total production area, making it the region with the highest brinjal production (Mannan *et al*., 2015).

A popular vegetable crop in many nations, including Central, South and South East Asia, as well as some portions of Africa and Central America, brinjal is utilized by the majority of people. It is indigenous to India and is cultivated all throughout the nation. It is a significant vegetable that is cultivated throughout the year. Unripe fruits are widely used as vegetables in the nation because of their nutritional worth, which includes minerals like calcium, phosphorus and iron as well as vitamins A, B and C.

Damage from it alone can reach 85.90%, while records show damage of up to 100%. Later, the larvae produced fragile fruits that were inappropriate for human consumption after boreging into tender shoots, causing withering and dead heart. As a fruit and branch borer in the main field of established brinjal, *L.orbonalis* is currently regarded as a significant pest Halder *et. al.*, (2015).

The brinjal shoot and fruit borer is one of the most destructive and monophagous pests, requiring the grower to apply 30-40 rounds of spraying. Serious infestations are also brought on by polyphagous insects such as aphids, leafhoppers, ash weevils and hadda beetles.

### 1. Shoot and fruit borer: *Leucinodes orbonalis* (Pyraustidae: Lepidoptera)

**Distribution and status**

India, Bangladesh, Malaysia, Thailand, Burma, Srilanka, Laos, South Africa, Congo. It is a major and regular pest of brinjal causing damage to even 30-50% of fruits or more.

**Host range:** Brinjal, potato other wild plants belonging to solanaceae, peas.

**Damage symptoms**

Larva bores into sensitive shoots, causing terminal shoots and dead hearts to wither. They also bore flower buds, developing buds and petioles of leaves, which causes the leaves to wither and the buds to shed, rendering fruits unfit for human consumption. Fruits that have been attacked have

| Major pests | | | | |
|---|---|---|---|---|
| **Sr.no.** | **Name of pests** | **Scientific Name** | **Family** | **Order** |
| 1. | Shoot and fruit borer | *Leucinodes orbonalis* | Pyraustidae | Lepidoptera |
| 2. | Hadda beetle | *Henosepilachna v punctata* | Coccinellidae | Coleoptera |
| 3. | Stem borer | *Euzophera perticella* | Phycitidae | Lepidoptera |
| 4. | Ash weevil | *Myllocerus discolor* | Curculionidae | Coleoptera |
| 5. | Brown leaf hopper | *Cestius phycitis* | Cicadellidae | Hemiptera |
| 6. | Aphid | *Aphisgossypii* | Aphididae | Hemiptera |
| **Minor pests** | | | | |
| 7. | Leaf hopper | *Amrasca devastans* | Cicadellidae | Hemiptera |
| 8. | Mealy bug | *Coccidohystrix insolitus* | Pseudococcidae | Hemiptera |
| 9. | Thrips | *Thrips tabaci* | Thripidae | Hemiptera |
| 10. | Spider mite | *Tetranychus cinnabarinus* | Tetranychidae | Acari |
| 11. | White fly | *Bemisia tabaci* | Aleyrodidae | Hemiptera |
| 12. | Leaf roller | *Antoba olivacea* | Noctuidae | Lepidoptera |
| 13. | Leaf miner | *Scrobipalpa blapsigona* | Gelechiidae | Lepidoptera |
| 14. | Hairy caterpillar | *Selepa celtis, S docilis* | Noctuidae | Lepidoptera |
| 15. | Grasshopper | *Oxya japonica, Poicilocerus pictus* | Acrididae | Orthoptera |

excreta-filled boreholes and become malformed.

**Bionomics:** Period of eggs: 3-4 days. Nestled on leaves, young shoots, blooms and developing fruits are 150-350 creamy white eggs. Stout and pink, the larva has a brownish head and sparsely spaced hairs on warts on the body. Larval period: 5 instars, 15 days. The pupa spends six to eight days in a strong, boat-shaped, grayish cocoon on the plant. Adult, medium size, white wings with triangular brown and red patterns flashing on the forewing. Life cycle: 17-50 days in total.

ETL: 1-5% shoots/ fruit damage.

**Management:** Remove the fruits with boreholes and the afflicted terminal shoot. Avoid growing brinjal all the time. In endemic regions, cultivate fruit cultivars with long, slender fruits. Set up a pheromone trap at 12/ha. Promote the larval parasitoids *Cremastus flavoorbitalis* and *Pristomerus testaceus* to be active. Steer clear of synthetic pyrethroids and insectici-des when fruit is ripening and ready to be harvested. One month after planting, begin spraying any of the following pesticides at 15-day intervals. Chlorpyrifos 20% EC 1.0 ml/lit, Emamectin benzoate 5% SG 4g/10 lit, Flubendiamide 20 WDG 7.5g/10 lit, Azadirachtin 1.0% EC (10000 ppm) 3.0ml/lit.

**2. Hadda/spotted beetle: *H.vigintioito punctata* (Coccinellidae: Coleoptera)**

**Distribution and status:** South Canada, USA, Mexico, Guatemala, Africa and South East Asia.

**Hostrange:** Brinjal, potato, tomato, cucurbitaceous plants, wild solanaceous plants.

**Damage symptoms:** The lower epidermis of leaves is scraped by both adults and grubs in a distinctive way, leaving stripes of uneaten areas behind. The leaves appear choked and in cases of severe infestation, all of the leaves may be eaten off, leaving just the veins intact (skeletonization), causing the plants to wither.

**Bionomics:** Period of eggs: 3-4 days. Nestled on leaves, young shoots, blooms and developing fruits are 150-350 creamy white eggs. Stout and pink, the larva has a brownish head and sparsely spaced hairs on warts on the body. Larval period: 5 instars, 15 days. The pupa spends six to eight days in a strong, boat-shaped, grayish cocoon on the plant. Adult, medium size, white wings with triangular brown and red patterns flashing on the forewing.

**Life cycle:** 17-50 days in total.

**ETL:** 1-5% shoot/fruit damage.

**Management:** Remove the fruits with boreholes and the afflicted terminal shoot. Avoid growing brinjal all the time. In endemic regions, cultivate fruit cultivars with long, slender fruits. Set up a pheromone trap at 12/ha. Promote the larval parasitoids *Cremastus flavoorbitalis* and *Pristomerus testaceus* to be active. Steer clear of synthetic pyrethroids and insectici-des when fruit is ripening and ready to be harvested. One month after planting, begin spraying any of the following pesticides at 15-day intervals. Chlorpyrifos 20% EC 1.0 ml/lit, Emamectin benzoate 5% SG 4 g/10 lit, Flubendiamide 20 WDG 7.5g/10 lit, Azadirachtin 1.0% EC (10000 ppm) 3.0ml/lit.

**3. Stem borer: *Euzophera perticella* (Phycitidae: Lepidoptera)**

**Distribution and status:** Indian sub-continent

**Host range:** Chilli, tomato, brinjal and potato.

**Damage symptoms:** Young and old plants' main stems are penetrated by larvae, which then descend. Young plants wither and their top shoots crumple. Stunted plants are older plants. It negatively impacts fruit-bearing capacity. The entrance location exhibits a noticeable thickening of the stem.

**Bionomics:** Period of eggs: 10 days. Scaly and creamy, they are deposited on young leaves, petioles and branches either individually or in clusters. 26 to 58 days for larvae. When fully developed, the larva is creamy white and has a few 20 mm bristle-like hairs. Pupa: 9-16 day old pups in a cocoon inside a larval tunnel. Adult: Greyish brown with white hind wings and transversely lined forewings. The life cycle takes 35-76 days to finish.

**Management:** Gather the dead and damaged plants and dispose of them. The infected plants should be removed and destroyed. Steer clear of ratoon cropping. To attract and kill adults, set up a light trap at one hectare. To lessen the occurrence of stem borer, add neem cake to the soil. Steer clear of synthetic pyrethriods that cause revival.

**4. Ash weevils: *Myllocerus subfasciatus, M. discolor, M. viridanus* (Curculionidae: Coleoptera)**

**Damage symptoms:** Adults notch the margins of their leaves. Grubs consume roots, which causes plants to wilt and eventually die.

**Bionomics:** 500 eggs in soil, 6-7 days. Grub: 30-45 days; Pupa: Pupates in soil in earthern cocoons; adult: 10-12 days. M. subfasciatus: Brown; M. discolor: Brown and white spots M. viridanus: Small light green weevil.

**Management:**

- Collect and destroy adults.
- Apply Neem cake @ 500 kg/ha at the time of last ploughing.
- In endemic areas apply carbofuran 3G@15kg/ha,15 days after planting.

**5. Brown leaf hopper: *Cestius phycitis* (Cicadellidae, Hemiptera)**

It is a vector for brinjal leaves. Nymphs and adults extract cell sap from the ventral side of the leaf and inject it into the plant tissues, resulting in shortened petioles, a reduction in leaf size, excessive branch growth, overall plant stunting, the transformation of floral parts into leafy structures, and a bushy appearance. Fruiting occurs infrequently. The mature leafhoppers are tiny, light brown, and have brilliant yellow markings on their thorax.

**Management**

a. As soon as infected plants emerge in the field, rogue out and eradicate them entirely.
b. Apply 750 ml of methyl parathion, 500 ml of dimethoate, or 125 ml of imidacloprid three to four times at 10-day intervals in 500-750 liters of water per hectare.

**6. Aphid: *Aphis gossypii* (Aphidiae: Hemiptera)**

The first instar grubs of *Chrysoperla carnea* can be released at a rate of 10,000/ha to manage it. Other options include spraying methyl demeton 25 EC or dimethoate 30 EC 500 ml, fenvalerate 20 EC 375-500 ml, phosphomidon 40 SL 625-750ml or thiometon 25 EC 1000 ml.

• Use light traps @ 2-3/ha to attract and kill the moths.
• Avoid using synthetic pyrethroids as they cause resurgence of sucking pests.
• Avoid using insecticide at the time of fruit maturation and harvest.
• Uproot and burn old plants before planting new plants since they harbour pest and carry over infestation.

**7. Jassids: *Amrasca biguttula biguttula***

**Host range:** Potato, Brinjal, Okra, Cotton and other malvaceous plants

**Mark of identification:** Adults are greenish yellow with two black dots on the head's vertex and a black patch on each of the front wings at the apical border. Additiona-lly, nymphs are green. They take a diagonal path.

**Symptoms**

• Yellowing of tender leaves.
• The margins of the leaves curl downward and turn red.
• "Hopper burn" is the term for the bronze turning of leaves caused by heavy infestations.
• When crushed, leaf margins shatter and crumble.

**Management**

Apply imidacloprid 17.8 SL or beta-cyfluthrin 8.49 + imidacloprid 19.81% OD to 10 liters of water. You can also remove and destroy any affected plants. Grow okra as a trap crop along the borders of a brinjal field.

**8. Aphids: *Aphis gossypii, Myzuspersicae***

**Host range:** Polyphagous feeding on potato, brinjal, cabbage, radish, chilli, tomato, tobacco, sunhemp, sweet potato etc

**Identification:** The adult is a little, soft-bodied, whitish insect with two cornicles on the dorsal side of the abdomen.

**Nature of damage:** Aphids cause discolouration, leaf curling, yellowing, and stunted growth in a wide range of host plants by sucking the fluids from the leaves and stems. A sticky, sweet waste product called honeydew can be produced by large infestations. Ants are drawn to honeydew, which also encourages the growth of fungi on plant surfaces.

**Management:** Spray the crop with Imidacloprid 70 WG @ 2-3 gms per 15 litter of water.

**9. Whitefly: *Bemisia tabaci***

**Symptoms:** Many bites and sap sucking slow down plant growth and can cause chlorosis on leaves; these insects produce a lot of honeydew, which is then colonized by opportunistic fungi that cause sooty mold.

**Life cycle:** Although their metamorphosis is straightforward, whiteflies differ significantly in appearance and behavior between the nymphal and adult phases. It takes 6-10 days for the egg to hatch, 3-4 days for the nymph I, 4-5 days for the nymph II, 4-5 days for the nymph III and 6-10 days for the pupa at 70ºF.

**Management:** Install yellow sticky traps. Spray the crop with Difenthiuron 50 WP @ 12g or Fenpropathrin 30EC @ 5ml or Thiamethoxam 25WG @ 4g or Pyriproxifen 5% + Fenpropathrin 15% EC @ 10ml/10 lit., water as soon as incidence is noticed.

## Conclusion

This book chapter "Integrated pest management of insect pest in brinjal", concludes that brinjalcrop alone has the largest production which compress about 90% of total production area and 17% of world production. But it is subjected to attack by number of insect pest from nursery tillharvesting. Among all insect pests, major ones are shoot and fruit borer (*Leucinodes orbonalis*),whitefly (*Bemisia tabaci*), leafhopper and non-insect pests such as spider mites of this, shoot andfruit is considered the main constraint as it damages crop throughout the year. Hence; the major and minor pests of brinjal along with the management was included in the chapter.

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# Revolutionizing Floriculture through Technological Advancements

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## Introduction

India's floriculture sector, with its vast range of agroclimatic zones, is evolving from traditional cultivation to modern, technology-driven practices, positioning the country as an emerging leader in the global market. The widespread adoption of these advancements hinges on strengthening research, training and farmer outreach through initiatives such as Precision Farming Development Centers (PFDCs) (Singh & Sharma, 2020). By integrating scientific innovation with agriculture, the sector is poised for a future marked by improved efficiency, higher profitability and environmental sustainability, ultimately enhancing its global competitiveness (Sharma *et al*., 2019). Post-harvest management has undergone significant transformation, with automated systems for sorting, grading and cold storage extending the shelf life of flowers while preserving their visual appeal (Chaudhary *et al*., 2021). AI-powered predictive analytics facilitate real-time detection of pests and diseases, optimize resource use and aid in climate adaptation, leading to healthier crops and improved yields (Rana *et al*., 2021). Emerging technologies like robotic harvesting and drone-assisted precision farming, demonstrated by projects such as RIPPA and RHEA are set to redefine field operations, driving both productivity and sustainability (Sharma *et. al*., 2022).

### The Role of Protected Cultivation

Protected cultivation, particularly within polyhouses, has empowered farmers to control key climatic variables such as temperature, humidity, light intensity and air circulation. This controlled environment facilitates the cultivation of high-quality, export-grade flowers, independent of external weather conditions (Bisht *et al*., 2020). Equipped with advanced auxiliary systems, polyhouses provide optimal growing conditions that enhance both yield and quality. Moreover, greenhouse technology has significantly increased land-use efficiency, enabling multiple harvests per unit area and outperforming traditional open-field cultivation in both productivity and profitability (Singh *et. al*., 2018).

### IoT-Driven Automation in Floriculture

The Internet of Things (IoT) is revolutionizing floriculture by integrating automation and precision into key cultivation processes. IoT-based fertigation systems enable the accurate delivery of water and nutrients, maintaining optimal electrical conductivity (EC) and pH levels. This precision not only conserves resources but also lowers production costs, resulting in higher yields

**Automated green house**

**Growing gerberas in a large green house in the Netherlands**

and superior flower quality. IoT operates through a network of intercon-nected devices and sensors that gather real-time data on critical parameters such as soil moisture, temperature, humidity and nutrient levels. This data is utilized by automated irrigation systems to optimize water usage, minimize waste and promote healthier plant growth (Singh *et. al.*, 2021). Additionally, IoT-driven climate control systems automatically regulate temperature and humidity within greenhouses, reduci-ng the need for manual adjustments and significantly enhancing operational efficiency. Moreover, IoT appli-cations extend to supply chain managem-ent, where sensors track produce from farm to market, ensuring quality, reducing spoilage and enhancing traceability (Kumar *et. al.*, 2020).

## Advancements in Post-Harvest Management

Post-harvest management is essential for preserving the freshness, appearance and overall quality of flowers. While traditional methods relied heavily on manual labor for sorting, grading and packaging, the industry is now adopting automated systems that minimize physical damage and extend shelf life (Chaudhary *et. al.*, 2021). These advanced technologies not only reduce labor costs but also improve operational efficiency, ensuring flowers maintain their aesthetic appeal and market value throughout the supply chain (Kumar *et al.*, 2022).

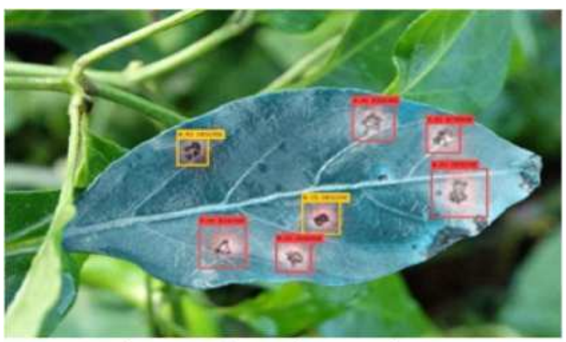
## The Rise of Artificial Intelligence in Floriculture

Artificial Intelligence (AI) is transforming floriculture by harnessing the power of predictive analytics and real-time data processing to enhance various aspects of cultivation and management. AI-driven systems facilitate early detection of pests and diseases, allowing for timely interventions that minimize crop losses (Rana *et. al.*, 2021). These technologies also optimize environmental conditions within growing spaces, improving plant resilience and overall health. AI plays a critical role in resource management by predicting the optimal timing for irrigation and fertilization, thereby reducing waste and increasing productivity (Sharma *et. al.*, 2022). With continuous advancements, AI is poised to introduce innovations such as robotic harvesting and personalized flower cultivation, further enhancing the sector's efficiency, precision and sustainability (Bisht *et al.*, 2020). Global initiatives are already showcasing the potential of AI in agriculture.

- **RIPPA (Robot for Intelligent Perception and Precision Application):** is a drone-like device designed to identify pests and diseases while applying chemicals with precision. It is a lightweight design and autonomous operation make it a promising tool for sustainable pest management (Rana *et. al*., 2021).

• **RHEA (Robot Fleets for Agriculture and Forestry Management):** integrates robotic systems into tractor units equipped with machine vision technology. These robots detect weed patches with up to 90% accuracy and eliminate them using a combination of physical and chemical methods, significantly reducing the need for broad-spectrum herbicides and enhancing crop management efficiency (Sharma *et. al*., 2022).

**RIPPA-Robot for Intelligent Perception and Precision Application**



**Disease detection and pest management**

**India's Flourishing Floriculture Industry**

India's vast and varied agroclimatic zones provide a favorable environment for the cultivation of a wide range of delicate flowers. Over the last three decades, the floriculture industry has undergone a significant transformation, shifting from traditional cultivation to large-scale commercial production. According to the National Horticulture Database (2020-21), the country has approximately 3,22,000 hectares dedicated to floriculture, producing 2.15 million tonnes of loose flowers and 8,28,000 tonnes of cut flowers. Key floriculture hubs include states such as Kerala, Tamil Nadu, Karnataka and Madhya Pradesh, where roses, tuberoses and marigolds dominate production (National Horticulture Board, 2021).

**Challenges and the Way Forward**

Despite its growth, the sector faces challenges in scaling smart technologies like IoT, AI and precision farming. Barriers include limited access to advanced technologies, lack of technical knowledge and financial constraints among small and marginal farmers. To unlock the full potential of these innovations, India must focus on enhancing research, providing technical training and raising farmer awareness (Singh & Sharma, 2020). Programs such as Precision Farming Develo-pment Centers (PFDCs) and collaborations with private enterprises can play a crucial role in facilitating the adoption of smart farming practices, ultimately boosting productivity, profitability and sustainability in India's floriculture industry (Sharma *et. al*., 2019).

**A Promising Future for Indian Floriculture**

The integration of cutting-edge technologies like the Internet of Things (IoT), Artificial Intelligence (AI) and cloud computing is set to revolutionize India's floriculture industry. This convergence of tradition with technology is driving innovation, sustainability and productivity, positioning the sector for substantial growth and global competitiveness (Sharma *et. al*., 2022). As these tools become more accessible to farmers, the industry is poised to achieve higher efficiency, reduced resource wastage and improved profitability. Emerging technologies are playing a pivotal role in this transformation. IoT-enabled devices, such as smart agricultural sensors, robotic drones, satellite imagery and GPS-equipped instruments, provide real-time data on critical parame-ters like soil health, crop status, localized weather conditions and resource availability (Kumar *et. al*., 2020). This data is seamlessly integrated with AI and machine learning (ML)-driven predictive analytics, enabling precise decision-making to optimize production and improve crop quality. By leveraging these advancements, floriculture is entering a new era where farmers can achieve higher yields, better-quality flowers and greater resilience against environmental challenges (Singh *et. al*., 2021). Additionally, this technological shift opens new opport-unities for research, innovation and the development of high-value nursery stock, making floriculture one of the most promising sectors in Indian agriculture (Sharma *et. al*., 2022).

## Conclusion

India's floriculture industry is rapidly evolving with the integration of advanced technologies like IoT, AI and cloud computing, driving efficiency, sustainability and profitability. These innovations enhance cultivation, post-harvest management and resource optimization, enabling higher yields and superior flower quality. While challenges like limited access to technology persist, focused efforts in research, training and public-private collaborations can bridge the gap. With its diverse agroclimatic zones and growing emphasis on modern practices, the industry is set to become a global leader, showcasing the transform-ative potential of technology in agriculture.

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# Biological Control of Weeds: Advancing Sustainable Agriculture Through Eco-Friendly Practices

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## Introduction

Biological weed control was developed from the inherent nature of organism's interactions to regulate weeds in agricultural ecosystems.It bases its principle on antagonism between the organisms. Zaber says, "Antagonism is the balance in the wheel of nature." It ensures biodiversity since no single group of organisms outgrows and overpopulates another species and this can be acknowledged between various ecosystems. Biological control models ensure there will be no disturbance of biodiversity as long as biological factors such as insects, pathogens and competitive plants exist within an agricultural ecosystem to regulate weeds. Biological techniques also maintain the diversity of natural competitors. On the other hand, biologically based herbicides would not cause any ecologic changes, such as the emergence of resistant grass weeds in wheat fields following the excessive use of chemical herbicides. For example, the excessive use of insecticides in cotton fields of India had shifted the ecology due to which the desired predatory species were exterminated and the population of pests like American bollworm became multi-folding. The biological control of weeds has proved Alexander Pope's principle of "live and let live"-the ideal for sustainable pest management that ensures the conservation of biodiversity and agricultural productivity. Biological weed control has become used in more than 90 countries as a safer alternative to chemical herbicides, but scepticism about its efficacy and safety continues (Cock *et. al.*, 2016).

In Asia, high levels of intensive cropping system dominate and herbicide use continues despite documented negative effects on human health and biodiversity (Igbedioh., 1991). Such increased dependency on synthetic herbicides has compounded alarm over environmental degradation including soil and water contamination, loss of biodiversity and development of herbicide-resistant weed populations. In addition, labour and herbicide cost is usually not very sustainable as the methods of manual weeding and herbicide applications tend to be economically uneconomical especially when dealing with perennial systems such as plantations and grazing areas (Davis *et. al.*, 2016).

**Example of Biological Control of Weeds using Insects**

Insects have often proven to be good agents of biological weed control, especially in application might disturb the balance of the larger ecosystem. The aggressive spreading of *Opuntia* species, also known as prickly pear, has been controlled by the introduction of relevant insect predators. In southern India, around 1863, the cochineal insect *Dactylopius ceylonicus* was introduced to control *Opuntia vulgaris*, demonstrating early success in this approach. In Australia, a combination of insects such as *Cactoblastis cactorum* (cactus moth) and *Dactylopius opuntiae* (another cochineal insect) can significantly control *Opuntia inermis* and *O. stricta*, primarily by destroying the aerial parts of plants and exposing them to pathogen infections through their feeding tunnels. The invasive weed *Lantana camara*, introduced from Central America, posed a severe problem in Hawaii's rangelands (1860s). Biological control efforts involved the use of several insect species the tortricid moth *Crocidosema lantana* and the seed fly *Agromyza lantanae* proved effective by targeting lantana's reproductive structures.

In India, Australia and Fiji, *Teleonemia scrupulosa* (lac bug) was one of the most efficient agents against lantana and was abetted by other insects like *Uroplata girardi* and *Octotoma scabripennis.*

The insects, like the Mexican beetle (*Zygogramma bicolorata*) and the gall insect (*Epiblema strenuana*), have been a significant effort in controlling the *Parthenium hysterophorus* weed species growing infectiv-elyin many areas. The results for Z. *bicolorata* have been encouraging in Australia and India, however, the lack of activity through-out winter has allowed parthenium to have a continuous crop throughout the year. This is a classic example of weed management by using insect.

In aquatic ecosystems, *Eichhornia crassipes* (water hyacinth) is another invasive species that has been beneficially controlled by insects. The most effective weevils are *Neochetina eichhorniae* and *Neochetina bruchii* since they bore into plant tissues, allowing soft-rotting bacteria to deteriorate the plant structure further. In some parts of Africa, the use of insects such as *Melanagromyza cuscutae* and *Smicronyx cuscutae* has made it possible to control Cuscuta species (dodder), a parasitic weed.

For terrestrial weeds like *Hypericum perforatum* (St. John's Wort) in Australia and in United States, *Chrysolina hyperici* and *Chrysolina quadrigemina* have been instrumental in reducing infestations in rangelands. Control of *Cyperus rotundus* (purple nutsedge) has also been achieved in India, Pakistan and the United States with the help of *Bactra verutana* (moth borer), which damages the tubers, thus impairing the weed's ability to spread. Likewise, the *Ludwigia species*, commonly found in rice fields, are reduced by *Haltica cyanea* (steel blue beetle). It very effectively reduces the growth of populations. Secondly, the gall midge (*Orseolia javanica*) has been shown to be one of the best control agents for *Imperata cylindrica* (thatch grass).

Such achievements indicate good approaches in the utilization of insects as positive tools in weed management within commun-ities, not to conflict with the approach of ecology but with biodiversity.

**Table1. Biological agents employed to control parthenium**

| Species and country origin | Host specificity | Countries, where introduced | Selected references |
|---|---|---|---|
| *Zygogramma bicolorata*<br><br>Origin: Mexico<br><br>*Epiblema strenuana*<br><br>Origin: Mexico | 51 species tested Australia adults can on several Compositae but larval development only on parthenium; feeds on *Ambrosia artemesiifolia* (weed) tested 11 cultivars sunflower; in India detailed study for controversy over its feeding on sunflower<br>49 species tested; also feeds on Ambrosia artemesiifolia Xanthium occidentale (weeds); further tests in India suggest niger seed can be attacked; this needs field verification in Australia. | Released in Australia in feed 1980-82 and established in 1990, restricted in Queensland with high Central in also impact Queensland; released in: Bangalore, India in 1984 & of established in 1984 with a high impact, further release in 1991 for the whole Karnataka state, India. Released in Australia in 1982-83 was and established in 1983, highly prevalent in Queensland having high impact on parthen-ium: However, populat-ion of Epiblema strenu-ana declines in dry weather | Jayanth. Jayanth 1987 and Nagarkatti, 1987. Jayanth *et. al.*, 1993 Kumar, 1993<br><br>Dhileepan *et. al.*, 1996<br>Navie *et. al.*, 1998 |
| Puccinia abrupta var. Partheniicola Origin: Mexico | 103 species and cultivars of sunflower tested | Released in Australia in 1991 and estd. in 1994: restricted to southern Queensland, initially promising results, but appeared to be limited by adverse weather, it is present in Kenya and may be useful in coffee against parthenium; the rust also present in Ethiopia, but severity of infestation varies, needs characterization. | |

**Biological Control of Weeds using Fungi**

Pathogenic fungi, particularly as bio-herbicides are also notable in weed suppression. In the United States, fungi like *Alternaria macrospora* and *Puccinia heterospora* have controlled. *Anoda cristata* by reducing critical reproductive factors such as pod and seed production.

For P. *hysterophorus, Puccinia abrupta var.*

*partheniicola* (originally imported to Australia from Mexico) has proven to be highly effective by infecting leaves, stems and flowers, promoting premature senescence and lowering biomass. Although this fungus has proven very effective in some specific climates, *Puccinia abrupta* has not performed as well in less favourable conditions and thus requires further development for wider use.

**Table 2. Mycoherbicide products and potential fungi bioagents in the world**

| Product and country | Bio-herbicide description | Target weeds and diseases caused | Crop where used |
|---|---|---|---|
| DeVine, 1981. USA | *Phytophthora citrophthora* p.v. *palmivora*. Soil-borne pathogen and can remain for 3-4 years in soil by one spray | *Morrenia odorata* (Strangler vine), (Lethal root-rot) | Citrus, USA: (Kenny, 1986) |
| Collego, 1982. USA<br>Biomal, Canada | *Colletotrichum gleosporioides* f. sp. Aeschynomene<br>*Colletotrichum gleosporioides* f. sp. *Malvae* | *Aeschynomene virginica* (Nothern joint vetch), (Stem and foliage blight) *Malva pusilla* (Round, leaved mallow, (Anthracnose) | Rice and soybean, USA; (Bowers, 1982) Cotton, Canada; (Makowski and Mortenson, 1992) |

**Biological Control of Weeds using Rhizobacteria**

Deleterious rhizobacteria (DRB) are non-infective bacteria that can inhibit plant growth and suppress rhizosphere micro-organisms, the rhizosphere of target weeds and depress root elongation and overall weed growth. They can colonize plant roots, seeds and rhizospheres and metabolize organic substances released by plant tissues. DRB can be used as a bioherbicide, but they can also stimulate plant growth. DRB has proven to be effective against *Bromus tectorum* (downy brome) in wheat fields and inhibits early weed development, thus improving crop competition.

Unlike traditional herbicides, DRB act primarily by growth suppression rather than eradication, often through the release of phytotoxins absorbed by weed roots. Field studies reveal improved crop yields when DRB reduce early weed competition, although their application is most effective under environmental conditions conducive to bacterial growth.

**Table 3. Rhizobacteria associated with weed-crop ecosystem**

| Rhizobacteria | Weeds | Ecosystems |
|---|---|---|
| Enterobacter | *Bromus tectorum* | Cereals |
| Enterobacter | *Amaranthus* sp. | Row crops |
| Pseudomonas | *Setaria viridis* | Cereals and range lands |
| Erwinia herbicola | *Setaria* sp. | Row crops |
| Pseudomonas | *Bromus japonicus* | Cereals |

**Biological Control of Weeds using Botanical Agents**

Another form of biocontrol is botanical agents or allelopathic plants. *Cassia sericea* and *Tagetes minuta* are competitive growers and have allelopathic properties, which make it possible to suppress the parthenium in India. In fact, seeds of *Cassia sericea* are made available to farmers of Karnataka to displace the natural parthenium plant, which is found invading such areas. In marshlands, *Panicum purpurascens* outcompetes Typha species and crops like barley, cowpea and sorghum contribute to weed management through the rapid development of canopy and competitive exclusion. For example, some weeds have been inhibited by sorghum, making high-canopy crops a crucial cultural method in integrated weed management systems.

**Table 4. Allelopathic effect of crops on weeds**

| Crops | Weeds | Source of inhibitors |
|---|---|---|
| Maize | *Chenopodium album, Amaranthus retroflexus* | Roots |
| Cassava | *Amaranthus dubius, Digitariasanguinalis* | Leaves |
| Sorghum | *Abutilon theophrasti, Setaria viridis* | Shoots and foliage |

**Table 5. Crop specific Biological control agents of weeds**

| Name of crop | Attacked weeds | Biological control agents of weeds |
|---|---|---|
| Rice | *Echinochloa* spp. | *Neochetina eichhorniae* (weevil) |
| Sugarcane | *Cyperus rotundus* | *Puccinia kuehnii* (Fungus) |
| Wheat | *Phalaris minor* | *Tilleia indica* (Fungus) |

**Table 6. Biological control agents of weeds**

| Name of biological control agents | Category of the bio-agent | Weeds managed |
|---|---|---|
| *Neochetina bruchi* | Insect | Water hyacinth (Eichhornia crassipes) |
| *Collectotrichum gloeosporoides* | Fungus | *Mikania micrantha* |
| *Azadiractin indica* (Neem) | Botanical product | Broadleaf weeds |

**Parthenium compost: an Eco-Friendly Technology to Convert Waste to Wealth**

P. *hysterophorus* has been linked to many health issues like dermatitis and respiratory allergy and it has allelopathy effects (toxin-parthenin) which causes a considerable reduction in crop output. P. hysterophorus has fresh biomass about 5-20 kg m-2 and 35 million lands are infested by it. As a result, parthenium management would continue to be a major issue for the country. A significant amount of agricultural production losses can be attributed to parthenium and regular application of synthetic chemical fertilizers exacerbates soil problems. One appropriate and affordable way to replenish soil nutrients could be through parthenium composting. Several studies suggested that parthenium can be utilized as compost, green manure and a soil ameliorant to potentially enhance physical, biological and chemical characteristics, by providing two times more easily accessible plant nutrients than farm yard manure. Farmers are worried that applying compost derived from biomass produced from Parthenium may cause additional weed germination in their crops, but scientifically prepared compost is balanced biofertilizer which is safe and beneficial to crop productivity and soil health. The effect of Parthenium compost is later but better. A better way of reducing parthenium's negative effects is to turn waste into wealth by turning it into compost (Mallick, H. K., 2024).

## Conclusion

The aim of weed management does not have the intention of killing weeds complet-ely but create a suitable balance which favours crops with maintaining biodiversity. A suitable combination of cultural, biologic-al, mechanical and chemical methods that are ecologically as well as economically viable is essential for sustainable agriculture. For the fact that there are more than 270 weed species resistant to herbicides, biological control has taken a vital role in future integrated weed management progr-ams. Herbicides are indeed useful but have introduced some challenges, such as shifting the weed flora, development of resistant species and ecological disturbances. Overreliance on herbicides alone disturbs ecological balance and can lead to an increase in the levels of resistant weed populations. Due to their dynamic nature, a more multi-faceted approach that integrates various methods is required. By targeting weeds specifically, biological control agents reduce the environmental impacts associated with chemical herbic-ides. Research should focus on identifying effective biological agents suitable for India's diverse agroecologies, which could significantly reduce depend-ency on chemical controls.

For effective long-term weed management, a systems based approach, including biological controls within IWM, is crucial. Further research, coupled with farmer education and outreach, will strengthen the adoption of biological weed control practic-es, promoting resilient and sustainable agricultural systems.

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# Production Technology of Sadabahar (*Vinca rosea* L.) var (*Vinca rosea* mix sunstorm)

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## Introduction

*Vinca rosea.* (Madagascar periwinkle) have several synonyms viz., *Ammocallis rosea* and *Lochnera rosea.* Other English names occasionally used for the Sadabahar is *Cape Periwinkle, Rose Periwinkle, Rosy Periwinkle* and *Old Maid*. It is popularly known as "Nayantara" or "Sadabahar", the word Catharanthus gets from the Greek language signifying "unadulterated blossom." While, roseus implies red, rose or blushing. It is an important medicinal plant of Family Apocynaceae containing abundant useful alkaloids, used treating in diabetes, blood pressure, asthma, constipation, cancer and menstrual problems. Vinblastine and vincristine are two powerful anticancer natural products, belonging to the group of terpenoid-indole alkaloids isolated from the pan tropical plant it is present only as minor constituents of the complex mixture of about 130 alkaloids produced by this plant. During the last 40 years vinblastine and vincristine have been used for the treatment and cure of thousands of patients, both because of their unique mode of action and their effectiveness. The plant has a long history of use in Ayurvedic medicine, traditional Chinese medicine and other healing systems. Western medical science began researching *Vinca rosea* and its extracts during the 20th century, finding several compounds useful in cancer treatment. All parts of the plant have been used in regional herbal medicine, including the dried root, leaves, flowers and stalks. Alkaloids used in modern medicine are extracted from the whole dried plant.

### Morphology

*Vinca rosea* is an evergreen sub herb or herbaceous plant. A native to Madagascar, this herbaceous plant grows to 80 cm to 1 m high and blooms continuously year-round with pink, purple or white flowers (Hogan, 2003) [1]. The leaves are oval to oblong, 2.5-9.0 cm. long and 1-3.5 cm. broad glossy green hairless with a pale midrib and a short petiole about 1- 1.8 cm. long and they are arranged in the opposite pairs. There are two common cultivars of *C. roseus* named on the basis of their flower colour, one producing pink flower "*Rosea*" (4) and the other, white flowers "*Alba*". The flowers are of various color namely white, dark pink , light pink , red and purple with a dark red centre, with a basal tube about 2.5- 3 cm. long and a corolla about 2-5 cm. diameter with five petal like lobes. The fruit is a pair of follicles about 2-4 cm. long and 3 mm broad. The plant grows widely to about 1m tall at subtropical areas. Its leaves are found to be of oval to oblong, 2.5- 9.0 cm long and 1.0-3.5 cm broad, glossy green, hairless, with a pale midrib and a short petiole of about 1.0- 1.8 cm long and they are arranged in the opposite pairs (Gajalakshmi *et. al.*, 2013) [2].

## Origin and Distribution

The plant is a native of Madagascar and from there it has spread to India, Indonesia, Indo-China, Philippines, South Africa, lsrael, USA and other parts of the world. In India, it is being grown in Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat and Assam in an area of about 3000 ha.

## Traditional and folkloric uses

There are many traditional and folkloric uses of sadabahar which are time-tested and confirmed with peoples' belief. The paste prepared from the leaves is considered to be excellent wound healer and also relieve from the wasp sting pain. It also helps in stopping bleeding, thereby quickening the healing process. Additionally, it is useful in bringing relief from depression, headaches and fatigue.

## Taxonomy

**Kingdom:** Plantae
**Division:** Magnoliophyta
**Class:** Magnoliopsida
**Order:** Gentianales
**Family:** Apocynaceae
**Genus:** Catharanthus
**Species:** roseus
**Common name:** Sadabahar, periwinkle

## Climate

The crop requires a warm and humid tropical climate for optimal growth, with temperatures ranging from 25ºC to 38ºC.

## Soil

Periwinkle can be cultivated in a wide range of soil types, including sandy loam, clay loam and laterite soils. However, it thrives best in well-drained, fertile soils with a pH range of 6.0 to 7.5.

## Varieties

Variety is *Vinca rosea* formula mix sun storm* 1k and its colour are Light Pink, Baby pink, Dark pink, Purple, Red and White.

## Propagation

It is easily propagated both by seeds or cuttings. About 2.5 kg seeds / ha is required for direct sowing and 0.5 kg seed/ ha for seedling transplantation. Periwinkle can be propagated through two methods: seed propagation or vegetative propagation.

## Cultivation

### i) Land Preparation

Proper field preparation is crucial for successful periwinkle cultivation. The land should be deeply ploughed and harrowed to achieve a fine tilth, ensuring good aeration and water infiltration. Well-decomposed farmyard manure or compost can be incorporated into the soil during land preparation to improve soil fertility and structure.

### ii) Transplanting

About 2.5 kg seeds/ ha is required for direct sowing and 0.5 kg seed/ha for seedling transplantation. For seed propagation, the seeds are sown in well-prepared nursery beds and the seedlings are transplanted to the main field after 4-6 weeks, when they have developed 4-6 true leaves. Alternatively, vegetative propagation involves planting stem cuttings of about 15-20cm length directly in the field or in nursery beds. Vegetative propagation ensures uniform growth and true to type characteristics of the desired variety. The planting distance varies depending on the cultivation method and variety. For transplanted seedlings, a spacing of 60cm x 45cm or 75cm x 45cm is recommended, while for direct seed sowning crops, a spacing of 45cm x 30cm or 60cm x 30cm is suitable. Proper spacing ensures adequate air circulation, light penetration and nutrient uptake, leading to optimal growth and alkaloid production.

### Manures and fertilisers

Sababahar is a heavy feeder and requires adequate nutrient supply for optimal growth and alkaloid production. A recom-mended dose of fertilizers, including nitro-gen, phosphorus and potassium, should be applied based on recommend-ations. In addition to inorganic fertilizers, organic manures like well-decomposed farmyard manure or vermicompost can be incorpor-ated into the soil to improve soil fertility and structure. These organic amen-dments not only provide essential nutrients but also enhance soil water-holding capacity, aeration and microbial activity, leading to better plant growth and alkaloid production.

**FYM**: 3200 to 4000 kg/ha and

**Vermicompost:** 1200 kg/ha

### Nutrient requirement (kg/ha)

In addition to inorganic fertilizers, organic manures like well-decomposed farmyard manure or vermicompost can be incorporated into the soil to improve soil fertility and structure. These organic amendments not only provide essential nutrients but also enhance soil water-holding capacity, aeration and microbial activity, leading to better plant growth and alkaloid production **N**- 30Kg/ha **P**- 50Kg/ha **K**- 40Kg/ha

### Irrigation

The crop requires frequent, light irrigations during the establishment phase and after each harvest to promote new growth and sustain alkaloid production. Drip or sprinkler irrigation systems are preferred for efficient water use and uniform distribution. These systems minimize water losses through evaporation and deep percolation, ensuring that the water reaches the root zone effectively. The amount and frequency of irrigation should be carefully determined based on factors such as soil type, climatic conditions, growth stage of the crop and water availability. Overwater-ing should be avoided as it can lead to waterlogging, root rot and other soil-borne diseases, ultimately affecting plant growth and alkaloid production

### Weed Control

This crop requires two weedings in the initial stages of its growth. The first weeding is to be done aroumd 60 days of sowing and the second weeding at completion of 120 days. Mulching with cut grass or rice-straw will also minimize the weed growth. Application of the chemical weedicide Sinhar at 4-5 kg/ha as a pre-emergent spray is highly effective against oil mount weeds similarly, the application of a mixture of 2-4-D and Grammaxone at the rate of 25 kg/ha to the soil before sowing keeps the weeds under control. Application of the chemical weedicide Sinhar at 4-5 kg/ha as a pre-emergent spray is highly effective against oil mount weeds similarly, the application of a mixture of 2-4-D and Grammaxone at the rate of 25 kg/ha to the soil before sowing keeps the weeds under control.

### Insect Pests and Diseases

Periwinkle is relatively resistant to pests and diseases compared to other crops. However, some common problems include root-knot nematodes, leaf miners and fungal diseases like leaf spot and root rot. Integrated pest management (IPM) practices is crucial for effective pest and disease management in Sababahar cultivation.

**Root-knot nematodes** (*Meloidogyne* spp.) are soil-borne pests that can cause significant damage to periwinkle roots, leading to stunted growth, wilting and reduced yields. Cultural practices like crop rotation with non-host crops, incorporating organic amendments like neem cake and using bio-nematicides or nematode-resistant varieties can help manage this pest.

**Leaf miners** (*Liriomyza* spp.) are insect pests that create tunnels or mines within the leaf tissues, causing discoloration and drying of leaves. Regular monitoring and timely application of neem-based insecticides or release of parasitoids like Diglyphus isaea can effectively control leaf miners.

**Fungal diseases** like leaf spot (caused by *Alternaria* spp., *Cercospora* spp., or *Colletotrichum* spp.) and root rot (caused by *Rhizoctonia solani*, *Fusarium* spp. or *Pythium* spp.) can also affect periwinkle cultivation. Maintaining proper soil drainage, avoiding excessive moisture and using disease-resistant varieties or biological control agents like *Trichoderma* spp. can help manage these diseases. Regular field monitoring, crop rotation, maintaining good soil health and implementing cultural, biological and chemical control measures (as a last resort) are essential components of an effective IPM strategy for periwinkle cultivation.

## Harvesting and Post-Harvest Handling

Sababahar is a perennial crop and the leaves and roots can be harvested multiple times a year. The optimal time for harvesting is when the plant has reached the flowering stage, as this is when the alkaloid content is highest. However, it is essential to follow the recommended harvesting intervals to ensure sustainable yields and maintain the plant's vigor.

### A) Harvest

#### i) Roots

The crops are harvested after 12 months of sowing. The plants are cut about 7.5 cm above the ground level and dried for the stems leaves and seeds. The field is then copiously irrigated and when a reaches the proper condition for digging, it is ploughed and the root are collect. The roots are later washed well and dried in the shade.

#### ii) Leaves, Stem and Seeds

If there is a demand for leaves, two leaf stripping, the first after 6 month and the second after 9 months of sowing can be taken. A third leaf stripping also obtained when whole plant is harvested. After the plant is harvested it is dried in the shade. It's second nodes dehiscene and releases the seeds with a light threshing which can be used for the next sowing.

The leaves and stems are also collected separately. It may be mentioned here; that the seeds collected in this way will have poor germination because they have been collected from pods in different degrades of maturity. Therefore, in order to obtain good seeds it is advisable to collect them from mature pods two to three months before the harvest of the crop. The aerial part of the plant between 7.5 cm and about 25 cm above the ground level is taken as the stem for the purpose of marketing. The total alkaloid content in the leaf varies from 0.15 to 1.34%, of which the average content of vinblastine is 0.002%, while that of vincristine is 0.005%.

### B) Post harvest handling

The leaves and roots are typically dried in the shade or using mechanical driers to reduce the moisture content to around 10%. Proper drying is crucial to prevent fungal growth and deterioration of the alkaloids. Once dried, the plant material is graded based on quality parameters like color, aroma and size. The graded material is then packed in airtight containers or polybags to prevent moisture absorption and deterioration. Proper storage conditions, such as cool and dry environments are essential to maintain the quality and potency of the alkaloids for an extended period.

## Yield (kg/ha)

**Plant part and their yield during Irrigated and Rainfed condition**

**Roots:** 1500kg/ ha in irrgated condition and 750 kg/ ha in rainfed conditon

**Stems-**1500kg/ ha in irrgated condition and 1000 kg/ha in rainfed conditon

**Leaves-**300 kg / ha in irrgated condition and 2000 kg/ha in rainfed conditon

### Value addition and marketing

The dried leaves and roots of Sababahar can be further processed to extract the valuable alkaloids such as vinblastine and vincristine, for use in pharmaceutical products. The extraction process involves various steps, including solvent extraction, purification and isolation of the desired alkaloids. Advanced extraction techniques, such as supercritical fluid extraction or ultrasound-assisted extraction, can improve the efficiency and yield of the alkaloid extraction process. The extracted alkaloids can be formulated into different dosage forms, such as injections, tablets or capsules, for cancer treatment. Collaboration with pharmaceutical companies and research institutions can facilitate the development of novel formulations.

### Conclusion

Advanced production techniques including proper soil and climatic conditions, field preparation, nutrient management, irrigation strategies, integrated pest and disease management, harvesting protocol and post-harvest handling procedures are crucial for achieving high yields and maintaining quality of alkaloids. Value addition and effective marketing strategies are also essential for enhancing the economic returns from periwinkle cultivation and meeting the growing demand for its valuable medicinal compounds.

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# Building Blocks of Regenerative Agriculture: A Path to Sustainable Agriculture

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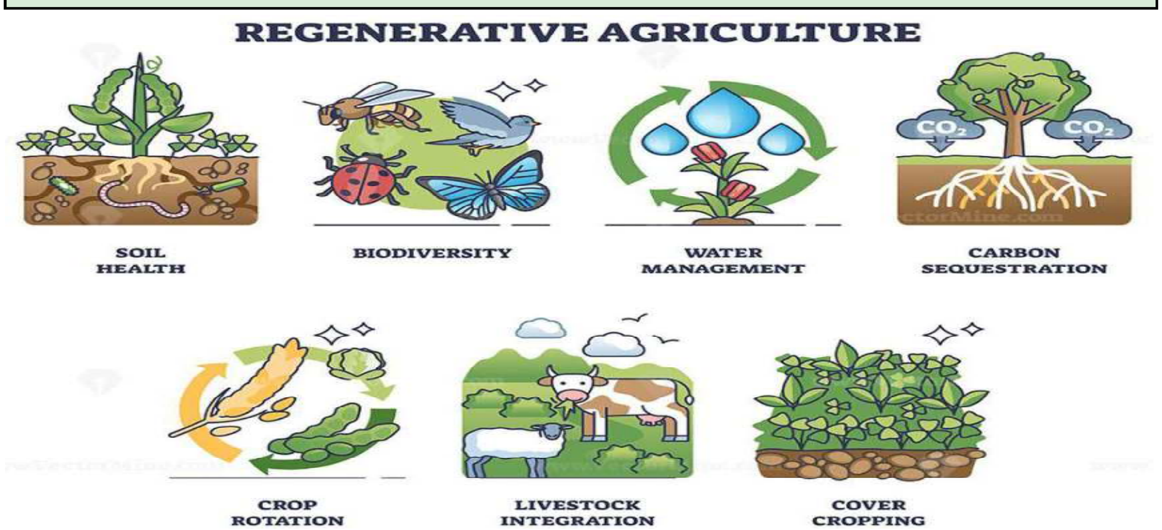
## Introduction

In order to prevent, for example, expansion into new areas at the expense of forest cutting, regenerative agriculture is a farming approach that seeks to restore soil and maintain its productivity for as long as feasible. In addition to growing crops to meet human requirements, soil fertility is necessary to provide cow feed. Animals get access to more food when pasturelands are more fruitful. Regenerative agriculture uses many techniques to address the problems caused by outdated farm management systems, combining traditional knowledge with digital solutions. In addition to preserving the fertility of already farmed land, regenerative agriculture techniques include unused or abandoned land that is no longer used for farming. This involves, among other things, ecological aquaculture, buffer zone fortification, peat land restoration and reforestation. Over time, these methods improve soil health, biodiversity and climate resilience while boosting agricultural productivity and profitability. They represent an upgrade over traditional agriculture



Instead of restoring the natural pre-agricultural ecology and biological function, RA aims to improve the health of farming systems by utilizing natural ecological processes. Rodale expanded the idea of regenerative organic farming to include some options that encompass a holistic approach with a focus on environmental and social improvements without the use of chemical fertilizers and pesticides. Gabel was the first to coin the term "regenerative agriculture." Since then, several researchers have proposed a number of definitions for RA. According to Francis *et al.*, RA limits the use of synthetic inputs while promoting the use of resources that can be found on the farm. The phrase is used by Project Drawdown to describe yearly agricultural systems that comprise at least

| RA Principles | RA Practices | RA Benefits |
|---|---|---|
| • Minimize Soil disturbance<br>• Keep soils covered<br>• Keep living roots in soil year round<br>• Encourage diversity<br>• Integrate Livestock | • No/Minimum tillage<br>• Stubble retention<br>• Diverse crop rotations<br>• Multispecies cover crops<br>• Intercropping<br>• Composting and use biostimulants<br>• Rotational grazing<br>• Reduce synthetic inputs | • Improved soil health through<br>• Increased soil carbon<br>• Improved microbial functions and associated nutrient cycling<br>• Improved soil moisture<br>• Nutrient rich food<br>• Reduced greenhouse gas emissions |

**RA (Regenerative Agriculture) principles, practices and purported benefits and mechanisms to improve soil health.**

### Key Principles of RA

• The removal of physical field treatment and mechanical methods. Techniques used in pre-industrial agriculture are consistent with this idea.

• Reducing erosion by using cover crops throughout the year to prevent bare soils. Additionally, this form of regenerative agriculture gives livestock and poultry pasture and feed.

• Increased biodiversity through methods including crop rotation, agroforestry and silvopasture.

• Using animals in the cultivation of crops.

• The maintenance of perennial crops' living roots.

• The use of chemical and biological inputs precisely.

### Benefits of Regenerative Agriculture

**1. Improved Soil Health:** RA practices significantly enhance soil health by increasing organic matter, improving microbial diversity and promoting better water retention. Healthy soils are more resilient to erosion, drought and nutrient depletion.

**2. Increased Soil Carbon:** RA can sequester carbon in the soil, helping mitigate climate change. Practices such as no-till farming, cover cropping and agroforestry contribute to carbon capture in soil organic matter.

**3. Enhanced Microbial Functions:** By promoting soil biodiversity and organic matter, RA enhances microbial processes that support nutrient cycling, reducing the need for synthetic fertilizers.

**4. Improved Water Management:** Healthy soils retain moisture better, making farms more resilient to drought and water scarcity, which are growing concerns in many parts of the world.

**5. Nutrient-Rich Food:** Crops grown using RA methods tend to have higher nutrient density due to improved soil health and reduced pesticide exposure.

**6. Reduced Greenhouse Gas Emissions:**

Reducing synthetic fertilizer use and promoting carbon sequestration in soil help lower the agricultural sector's overall greenhouse gas emissions.

**Key Practices and Benefits of implementing of RA**

**1. Soil Health Focus:** RA prioritizes soil health, aiming to restore the soil's natural functions and ensure long-term productivity. By improving soil organic matter and microbial activity, RA enhances soil's ability to retain nutrients and water, which ultimately supports higher yields and biodiversity.

**2. Crop Rotation:** Crop rotation helps break pest cycles, reduce soil erosion and improve soil fertility. By diversifying crops, farms can reduce dependence on chemical inputs and improve ecosystem resilience.

**3. Cover Cropping:** Cover crops are integral to RA systems, helping maintain soil cover, improve soil structure, increase organic matter and reduce erosion. They also support beneficial insects and promote biodiversity by providing habitat for pollinators.

**4. Animal Integration:** The integration of livestock into cropping systems, such as through rotational grazing, helps to improve soil fertility. Manure from livestock adds organic matter to the soil, increasing its microbial activity and carbon content. Managed grazing also reduces the need for synthetic fertilizers and supports soil regeneration.

**5. Organic Inputs:** RA reduces reliance on synthetic fertilizers and pesticides, using organic inputs like compost, manure and biostimulants to nourish the soil. These inputs help maintain soil fertility without the environmental costs associated with synthetic chemicals.

**Conclusion**

The core of regenerative agriculture is soil health, a crucial yet finite resource. This strategy seeks to enhance ecosystem health, reduce carbon footprints, improve soil quality and make agricultural products safer for human consumption. It's incredible that a strategy that enhances food production and agriculture also helps against climate change. Regenerative agriculture methods will probably become more common as a result of legislative actions and commercial forces. Local soil health can be enhanced in the meanwhile by regenerative agriculture cooperatives and individual farms. Businesses' efforts to cultivate crops sustainably could have a significant positive impact on our common environment.

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# Scientific Cultivation of Custard Apple in Jharkhand

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## Introduction

Custard apple (*Annona squamosa* L.) belongs to the Annonaceae family and originated from tropical America. Custard apple is also known as sugar apple, sweet sop, sitaphal in South India, Sharifa in North India and Aata in West Bengal.The Annonaceae family have 500-600 species (Bailey 1949). It is a tropical fruit crop and extremely valuable due to its delicious and creamy flesh. Its plant is generally semi-deciduous, erect, woody plant height short to medium and the fruit are heart-shaped with size also medium size.

### Soil and climate

In Jharkhand custard apple are generally grown in waste ground, poor sandy or limestone soil and they produce good yields. It is a very hardy plant and it survives in 25 to 41°C in summer. The optimum temperature for good cultivation and pollination is 25°C and high relative humidity (80%).

### Area and production

Custard apple is the most important crop in tropical and subtropical conditions. Custard apple is widely grown in different states of India, including Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, Assam, Uttar Pradesh, Bihar, Rajasthan, Andhra Pradesh and Tamil Nadu (Nag *et. al.*, 2018). The total cultivation area for this fruit is reported to be 40,000 hectares and the total production of custard apple in Indiais 387,260 tonnes during 2021-2022. Maharashtra is the largest producer of custard apple in India. In Jharkhand, the custard apple area is 380 hectares and production is 440 MT from 2022 to 2023 (www.agriwelfare.gov.in).

### Nutrition value

They contain a lot of carbohydrates (23.0 g/100 g) and are used in ice cream. Moisture (70.5 g), fiber (3.1 g), protein (1.6 g), fat (0.4 g), minerals (0.9 g), calcium (17.0 mg), phosphorus (47.0 mg), iron (1.5 mg), thiamine (0.07 mg), riboflavin (0.17 mg), niacin (1.30 mg) and vitamin C (37.0 mg) make up the fruit, which has an energy value of 104 Kcal (Goutam *et. al.*, 2019).

### Varieties

Mosty in Jharkhand, custard apple seedlings are found in the wildform, following varieties commercially grown by progressive farmers.

- ANM 1
- Balanagar
- Arka Sahan
- Red Sitaphal
- Local Sitaphal

**Propagation**

In Jharkhand, custard apple is propagated by seed. The highest seed viability was found in custard apple is 3-4 years. Generally, 18-month-old tall plants having pencil thickness are selected for grafting. The best method of propagation in custard apple is veneer or cleft grafting.

**Flowering physiology**

The custard apple flower is hermaphrodite, with the male and female parts of the flower mature before the pollen is released from the anther. Typically, the custard apple flower blooms from March to July and bears fruit in June to July. Cross pollination occurs in the custard apple and it takes 5 to 6 months from pollination to fruiting. The flower lacks nectar to attract pollinators, with the exception of certain Niti dulid beetles. Farmers used hand pollination for commercial custard apple cultivation.

**Fig. 1 Plant, flower, immature fruit and mature fruits of custard apple.**

**Cultivation**

- **Planting:** Pits size for custard apple cultivation 60 cm×60 cm × 60 cm dug and left open to sun for a week. Custard apple is generally planted at 5 m × 5 m apart (400 plants/ha) and for good pollination, 4 m× 4 m (625 plants /ha) promotesa good fruit set. The rainy season is a good time for planting.
- **Pruning:** Pruning and training have an impact on custard apples by maintaining the vegetative and reproductive phases. In general, custard apples don't need much pruning. Keep a single stem 50-60 cm above the ground throughout the primary stage. In the fall, trim the scion at a certain height to promote branching and achieve consistent branching, which will give the tree the correct shape.
- **Manuring and fertilizer:** Applying fertilizer and manures to custard apples is uncommon in Jharkhand. Fertilization is highly effective in boosting a plant's vigour, output and fruit quality. According to Anonymous (1981), the suggested dosage for custard apple NPK is 250:125:125 g.

**Irrigation:** The production of custard apples is moderate even without irrigation. During flowering and fruiting, irrigation is crucial. Irrigated plants have more edible pulp and better fruit quality. In Jharkhand, there is a limited source of irrigation, so generally, custard apple is produced without irrigation.

### Physiological disorder

• **Tree decline:** This is major disorder in Jharkhand after 10 years plant die.

• **Woodiness:** Seed pockets and gritted lumps in the flesh.

• **Stone fruits:** Major physiological disorder remaining fruits turn brown and hard.

• **Fruit splitting:** Unexpected variations in fruit temperature or moisture content are most likely to blame.

• **Crocodile skin:** Carpels on fruits are pointy and wavy.

• **Russeting:** It is caused by low temperature (lower then 13°C) and low humidity.

### Diseases

• **Damping off (*Rhizoctonia solani* and *Fusarium* spp.)**

Fungi cause it and affect in roots of custard apple plants.

• **Anthracnose & fruit rot: (*Colletotrichum gloeosporioides*)**

The infection starts at the fruit's blossom end and eventually spreads to the whole fruit surface. Affected fruits shrivel and may fall or cling to the tree.

• **Black canker (*Phomopsis* spp)**

Irregularly shaped patches that can be big blotches or tiny specks. Spots have a vague "feathered" border.

### Disease management

• Remove affected plants from field.

• Remove affected fruits from custard apple plant.

• Spray with copper oxychloride 0.2 percent or benomyl at 0.1 percent

### Insect and pest

• **Mealy bugs:** Typically consume plant sap, which results in the production of honey dew, stunted growth and yellowing of the leaves.

• **Fruit fly:** Maggots consume the pulp after boring into the partially ripened fruits. Fruits that are impacted shrivel, deform, rot and fall.

### Insect management

• Spray of Dichlorvos @1.5 ml/ litre on two successive days will give respite from their attack.

• Mealy bugs can also biological control by its predator *cryptolaemus montrouzieri.*

### Harvesting

The custard apple is a climacteric fruit, it is picked when it reaches maturity and begins to turn from green to its varietal color shade. Fruits that are immature do not ripen. Another sign of maturity is the swallowing of some apical buds, which reveal inner pulp. More than 100 fruits weighing 300-400 grams are produced by a tree that is grown. Optimum harvesting time in Jharkhand state is Oct. to Nov.

### Post-Harvest Management

To preserve the quality and shelf life of custard apples, post-harvest handling is essential. Among the sustainable post-harvest methods are:

• **Sorting and Grading:** Arrange fruits according to their size and quality, throwing away any that are ill or broken.

• **Packaging:** When transporting fruits, use environmentally friendly packaging materials such as biodegradable crates, baskets or cartons.

### Value Addition

Make custard apple into value-added goods that can sell for more money, like jams, pulp, juices or desserts.

• **Ice cream:** It is possible to incorporate custard apple pulp into ice cream. According to one study, the most palatable ice cream was made with 100% pulp, 50% whipping cream, 20% condensed milk, 5% sugar and 5% milk powder.

### Sustainable Methods for Successful Farming in the Long Run

In addition to helping the environment

sustainable custard apple farming guarantees farmers' long-term productivity. Here are some more suggestions for sustainability:

• **Agroforestry:** Consider growing custard apples as part of an agroforestry system, which plants custard apple trees next to other trees or crops. This encourages ecological balance, lessens soil erosion and increases biodiversity.

• **Crop rotation:** To naturally increase soil fertility and lessen pest pressure, alternate custard apple trees with leguminous cover crops.

• **Community Farming:** Promote group farming methods in nearby communities. This lowers individual costs and promotes sustainable farming on a larger scale by enabling farmers to share resources like water, organic inputs, and knowledge.

**Conclusion**

The state's ideal climate, soil and farming methods make Jharkhand a promising place for the scientific cultivation of custard apples. Farmers can increase fruit yields and quality through applying new techniques like integrated pest management, vegetative propagation, effective irrigation systems and appropriate soil management. In Jharkhand, the establishment of custard apple orchards can boost the state's economy, especially in rural areas, by providing a different source of income from the production of both fresh fruit and processed goods. Additionally, growing custard apples can be a vital part of boosting the local economy and creating jobs due to the growing demand for tropical fruits. The region's successful and long-term custard apple cultivation will be further guaranteed by appropriate education and extension services.

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# Production Technology of Brahmi (*Bacopa monnieri*) var. (CIM-Jagriti)

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## Introduction

Brahmi (*Bacopa monnieri*) is a perennial, herbaceous plant native to wetlands and tropical climates of Asia, Africa and North America. It is a member of the Scrophulariaceae family and is known for its distinctive creeping growth habit, succulent, elongated leaves and small white or purple flowers. In Ayurvedic medicine, Brahmi has a long-standing reputation as a "brain tonic" due to its cognitive-enhancing properties. It is widely recognized for its ability to improve memory, mental clarity and concentration, earning it a place as one of the most revered herbs in traditional Indian medicine.

The name "Brahmi" is derived from the Hindu god Brahma, symbolizing its revered status in promoting mental well-being and enlightenment. Over centuries, Brahmi has been used to treat a variety of ailments, ranging from cognitive disorders like dementia and Alzheimer's to stress, anxiety and epilepsy. This versatile plant is believed to work as a powerful adaptogen, balancing the body's stress response and helping to restore mental and physical equilibrium. The active compounds responsible for Brahmi's therapeutic effects are primarily bacosides-saponin glycosides that support brain function by promoting the regeneration of neurons and improving neurotransmission. Modern research has increasingly focused on these bioactive compounds, which exhibit antioxidant, anti-inflammatory and neuroprotective properties. In addition to its cognitive benefits, Brahmi has been studied for its positive impact on cardiovascular health, immune function and skin health, making it a versatile and valuable plant in both traditional and contemporary wellness practices. In addition, it was also reported to possess anti inflammatory, analgesic, antipyretic, sedative, free radical scavenging and anti-lipid peroxidative activities

(Anbarasi *et al*, 2005; Kishor and Singh, 2005).

Given its extensive medicinal uses and growing scientific interest, Brahmi has become a subject of research in pharmacology and phytochemistry, with studies aiming to better understand its mechanisms of action, safety and potential for use in modern medicine.

**Origin & Distribution**

It is native to India, Bangladesh and Southern Asia. Typically, this plant thrives in marshes, damp soil and shallow water. Nepal, India, Sri Lanka, China, Taiwan, Pakistan, Vietnam, Florida and the southern United States are among the nations where it is most prevalent. It is mostly found in tropical areas of India. With the exception of India, it is found in warmer parts of the world.

**Taxonomy**

**Kingdom:** Plantae
**Division:** Anthophyta
**Class:** Magnoliopsida
**Order:** Scrophulariales
**Family:** Scorphulariaceae

**Climate & Soil**

Brahmi thrives best in clayey and sandy loam soils, but it may also be cultivated in a variety of soil types with some shade and a good supply of moisture. It grows effectively on normal soil pH in subtropical climates. The plants develop quicker at higher temperatures (33-40°C) and demand a high amount of humidity of 65 to 80%. They should be cultivated in summer as the rainy season begins. It becomes dormant during the winter months except when grown near running water.

**Varieties**

In terms of yield and bacoside content, saplings from the River Ravi's catchment areas have outperformed those from the Indo-Gangetic plains. Three cultivars of this crop have also been created by the Central Institute of Medicinal and Aromatic Plants or CIMAP, in Lucknow and these are the most popular varieties cultivated in India.

**Propagation**

For planting, it is best to use fresh plant cuttings that are around 4-5 cm in length and retain a few leaves, nodes and roots. The seeds are tiny and have a low germination rate so the best way to propagate is through plantings. These cuttings are rooted within 8-10 days and becomes ready to transplant in the main field.

| Varieties | Characteristics | Released from |
|---|---|---|
| Subodhak | It is a selection from wild collections providing a dryherb yield of 47 quintals / hectare/harvest (with 1.6% bacoside A) | CIMAP Lucknow |
| Pragya-Shakti | It is a selection from Orissa with dry herb yield of 65 quintals/hectare/harvest (with 1.8% bacoside A) | CIMAP Lucknow |
| CIM- Jagriti | It is perennial in nature and has a potential of producing 85 kg/hectare of bacoside A from a dry herb yield of 40 quintals /hectare. Has purple flowers | CIMAP Lucknow |

**Cultivation**

**(i) Land Preparation:** Brahmi prefers clayey or loamy soils with good moisture retention. Soil that can hold water without becoming overly compacted is ideal. Brahmi plantation needs well-pulverized and levelled soil. Clear the field of all weeds, stones and debris. Weeds can compete with Brahmi for nutrients, water and space, reducing the overall yield. Plough the field 2-3 times to a depth of about 10-15 cm to loosen the soil. This helps in aerating the soil and encourages root growth. After ploughing, use a tiller to break up the clods and create a fine, crumbly texture for planting. This ensures good seed-to-soil contact for Brahmi cuttings or seedlings. The area should be completely ploughed, crushed and made weed-free. Ploughing and harrowing are required to achieve a fine tilth in the soil. When land is transformed into plots, irrigation is recommended to keep the land moist so that the planting becomes easy. Application of FYM@20q/ acre is to be mixed with soil during ploughing. Allow the prepared land to settle for 7-10 days before planting to allow proper decomposition of organic matter. Once the land is prepared, you can proceed with transplanting rooted cuttings.

**(ii) Transplanting:** It is transplanted during June- July and is done with fresh plant cuttings that are 4-5 cm long and are planted at a distance of 20 x 20 cm. Plant the cuttings during early morning or late afternoon to reduce stress on the plants due to high temperatures. For transplanting from cuttings, ensure the stem is buried at least 2-3 cm deep into the soil. A light irrigation is strictly recommended for better establishment and survival of the plants. Avoid over-watering immediately after transplanting, as it can cause waterlogging and root rot. Maintain consistent moisture levels.

**Fertilizer**

**Organic Fertilizer Requirement (kg/ha$^{-1}$)**

By maintaining soil health with proper organic fertilization and composting, you can create an environment that favors the growth of Brahmi. Soil amendment with compost or organic matter also promotes beneficial soil organisms that can naturally suppress weed growth. The recommended dose of FYM is 5 t/ha$^{-1}$ and 2-5 t/ha$^{-1}$ of Vermicompost for Brahmi. Organic fertilizers like FYM and vermicompost provide nutrients slowly, ensuring sustained plant growth over time.

**Nutrient requirement (kg/ha$^{-1}$)**

Use nitrogen as a top dressing in split doses. Apply other fertilizers based on plant growth stages and soil nutrient availability. Apply P as a basal dose during land preparation or as a top dressing during the growing season. Potassium improves plant resistance to diseases, regulates water use and enhances overall plant health. The recommended dose of NPK for Brahmi is 100:60:50 kg/ha$^{-1}$

**Weed Control**

Hand Weeding is recommended to keep the field weed free. Three to four hand weedings are recommended every 15-20 days for optimal establishment and growth. To ensure that the soil surrounding Brahmi roots is not overly disturbed, weeds can be pulled by hand or with the use of equipment like hoes or weed-pullers.

**Irrigation**

Brahmi is a water-loving, semi-aquatic plant that thrives in moist, wetland environments. Proper irrigation is critical for its healthy growth and to maximize its medicinal and therapeutic benefits. Brahmi requires regular watering to maintain consistent soil moisture. Irrigate the plants when the topsoil feels dry. During monsoon, the field should be fully weed-free. Every 8 to 10 days, the fields are irrigated by flooding to meet the requirements. Irrigation can be avoided during the monsoon season. Brahmi plants are susceptible to root rot if the soil becomes excessively waterlogged, so it's essential to avoid over-irrigation. Proper drainage is important to allow excess water to escape.

**Plant Protection**

**Pest & Their Control**

**Sphinx catterpillar:** It is stout, pale grey on colour and has horn like tail. It is a polyphagous pest that attacks the leaves of the plant. The caterpillar feeds on the leaves and stems, which can reduce the plant's growth, vigor and overall yield.

**Control:** To control the pest you can hand pick the catterpillars and dispose them far away from the main field. Deep ploughing exposes the pupae for predation to insectivorous birds. Encourage natural predators like lady birds, wasps, birds to help control pest population.

**Grasshopper:** These are insects that feed on the leaves of the plant and destroys the overall plant if the infestation is small, simply removing the grasshoppers can help control the population. Grasshoppers are usually visible during the day. They are green, brown or yellowish in color and can be seen hopping around or resting on the plants. Dark green or brown droppings may be found on the plants or the soil near them, signaling an active infestation.

**Control:** To control this pest use a neem based spray insecticide. Predators that eat grasshoppers in the egg phase of life are bee flies, blister beetles, crickets, ground beetles and other insects. Some adults of these insects such as the field cricket can destroy up to 50% of the egg population in one area. Natural enemies of nymphals and adult grasshoppers would be birds, spiders and rodents. You can also plant grasshopper-attracting crops near Brahmi to divert the grasshoppers away from your main crop.

**Harvesting**

Harvest the plants between October-November to prevent loss of biomass and bacoside production.

So that the higher portions of the stem 4-5 cm from the base are removed and the remainder is left for renewal. Brahmi is a perennial herb and can be harvested 2-3 times a year under optimal conditions. Drain excess water before harvesting to simplify the process and avoid damage to the plant parts. Harvest during the early morning or late afternoon to retain moisture in the plant parts and reduce wilting.

**Post Harvest management**

**Washing:** Clean the harvested plant material in fresh water to remove dirt or mud.

**Drying:** Dry in shade or use mechanical dryers at a temperature of 40-50°C to retain active compounds (bacosides). To sun dry brahmi, spread the fresh material in a single layer on a polythene sheet and leave it in the open sun, turning it occasionally.

**Storage:** Store the dried material in airtight containers or bags in a cool, dry place to maintain quality.

**Yield and Economics**

Brahmi can yield approximately 5-8 tons of fresh leaves per hectare per year, depending on the quality of care provided during cultivation. Brahmi has a high demand in the herbal medicine market, especially for cognitive health and is widely used in formulations such as teas, capsules and oils.

**Value Addition**

After harvesting, Brahmi leaves can be

dried and processed into various forms, such as powders, oils, tinctures or capsules, depending on market demand. The value-added products have a higher market price, increasing the profitability of Brahmi cultivation.

**Conclusion**

In conclusion, planting Brahmi is a practical and beneficial endeavor for anyone looking to enhance their garden with a versatile, medicinal herb while promoting a sustainable and healthy lifestyle as it cost-effective and ensures a fresh, organic supply of this beneficial herb, contributes to soil conservation, reduces weed growth and supports a green and sustainable environment, gain access to a natural source of therapeutic properties that can support cognitive health, stress relief and general well-being.

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# The Hidden Value of Cucurbit Vines Residues

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## Introduction

Cucurbit aceous crops, including cucumbers, pumpkins, melons and squashes, produce significant vine residues after harvesting. Traditionally discarded, these residues present environmental concerns and missed opportunities for sustainable use. Recent innovations are uncovering ways to repurpose these residues for eco-friendly applications, adding economic value and contributing to food security and economic stability. This article explores the innovative uses of cucurbitaceous vine residues and their prospects.

**What are Cucurbit Vine Residues?** Cucurbit vine residues refer to leftover plant material from crops like pumpkins, cucumbers, melons, squash and gourds, including stems, leaves, vines and non-edible fruit.

### Characteristics of Cucurbit Vine Residues

1. **Stems:** Thick, sometimes woody.
2. **Leaves:** Large, broad, photosynthe sizing.
3. **Vines:** Long, creeping stems.
4. **Old or Damaged Fruit:** Inedible or unharvested fruit.

### Nutrient Composition

- **Macronutrients:** Nitrogen (1.2%), Phosphorus (0.1%), Potassium (1.5%), Calcium (0.4%), Magnesium (0.2%), Sulfur (0.1%)
- **Organic Matter:** Up to 90%
- **Carbon:** Good for composting (C:N ratio of 20:1 to 30:1)

Impact on Soil Fertility

- **Carbon Contribution:** Improves soil structure, water retention and microbial activity.

• **Nitrogen:** Enhances soil nitrogen content.
• **Potassium:** Helps regulate water uptake and increases plant resilience.

**Major Constituents**

• **Polysaccharides:** Pectins and cellulose, acting as soluble fiber.
• **Proteins and Amino Acids:** Contributing to plant growth and nutrition.
• **Fatty Acids:** Linoleic acid, mainly in seeds
• **Vitamins:** Vitamin C, Vitamin A, B vitamins.
• **Minerals:** Calcium, potassium, magnesium, phosphorus.
• **Phenolic Compounds:** Antioxidants protecting against oxidative stress.
• **Water:** Aiding in nutrient transport and hydration.

**Alkaloids in Cucurbit Vines**

1. **Cucurbitacins:** These are tetracyclic triterpenes found in bitter parts like stems, leaves and unripe fruits of cucurbits. They can cause bitterness and toxicity in high amounts. Types include Cucurbitacin A, B, D and E and they have several biological activities:
• **Anticancer properties:** Potential to inhibit cancer cell growth.
• **Anti-inflammatory effects:** May help reduce inflammation.
• **Antimicrobial activity:** Exhibits antimicrobial properties.

**Residue Overview:** After harvesting crops like squash, pumpkins and melons, significant plant residues (vines, leaves and stems) remain in the fields. These residues, rich in organic matter and nutrients are often discarded, leading to waste buildup, pests, pathogens and potential soil health issues. Given the extensive global cultivation of cucurbits, substantial post-harvest residue is generated. Repurposing these by-products can minimize agricultural waste and add value to cucurbit production.

**Current Uses of Cucurbit Vine Residue**

• **Livestock Feed:** Vines, leaves and other parts are used as low-cost feed for cattle, goats and poultry, though nutritional value varies.
• **Composting:** Commonly composted to improve soil fertility, adding organic matter, enhancing soil structure and water retention.
• **Bioenergy:** Processed for biogas production through anaerobic digestion, converting organic matter into renewable energy.

These uses, while valuable, remain limited and much of the potential of cucurbit vine residues is untapped.

**The Need for Innovation:** Cucurbit vine residues, including vines, leaves and stems are underutilized resources rich in organic matter, fibers and bioactive compounds. They hold potential for sustainable materials (e.g., biodegradable packaging, natural fibers), alternative energy sources (biofuels), soil health enhancement, high-quality fertilizers and new pathways in pharmaceuticals and nutraceuticals. Utilizing these by-products could unlock new economic opportunities and promote a more sustainable agricultural system.

Future Potential and Innovative Uses

**1. Nutrient-Rich Compost and Soil Amendments:** Cucurbit vine residues are rich in organic matter and nutrients, making them ideal for compost production. Composting these residues improves soil structure, moisture retention and microbial activity, reducing dependency on chemical fertilizers. Future prospects include developing region-specific composting practices and enriching compost with bio-stimulants.

**2. Biochar Production for Carbon Sequestration:** Biochar, produced by pyrolyzing cucurbit vine residues, improves soil fertility, enhances moisture retention and sequesters carbon dioxide, combating climate change. It can also filter heavy metals and toxins from soils. Future research could optimize biochar production and create customized biochar products for specific soil types or crops.

**3. Livestock Feed Supplement:** Cucurbit vine residues, containing fiber, minerals and protein, can be processed into silage or pellets for livestock feed. This offers an economical feed alternative, benefiting small-scale farmers and reducing waste. Advances in feed processing technologies could enable the safe conversion of residues into high-quality livestock feed, with further research into nutritional optimiz-ation.

**4. Paper and Packaging Material Production:** Cucurbit vine residues are fibrous and suitable for producing paper and biodegradable packaging. This process reduces reliance on wood pulp and offers an eco-friendly alternative to plastic. Future prospects include scaling up production and developing region-specific units for accessible, affordable materials.

**5. Natural Fiber Extraction for Textiles:** Fibers from cucurbit vines can be extracted for the textile industry, creating eco-friendly products like bags, mats and sustainable apparel. This innovation supports the demand for biodegradable fashion and benefits rural economies by creating job opportunities. Future prospects include collaboration between agriculture and textile sectors for sustainable clothing lines.

**6. Biofuel and Biogas Production:** Cucurbit residues can be converted into biofuel through anaerobic digestion or fermentation, producing biogas for cooking, heating and electricity. This renewable energy source reduces fossil fuel dependence. Future prospects involve investing in biogas infrastructure and optimizing biofuel yields, especially in rural areas.

**7. Extraction of Bioactive Compounds for Pharmaceuticals:** Cucurbitaceous plants contain bioactive compounds like cucurbitacin, flavonoids and saponins with medicinal applications. Extracting these compounds from vine residues could supply the pharmaceutical and nutraceutical industries. These compounds have anti-inflammatory, anticancer and antimicrobial properties. Prospects include advancing extraction techniques to produce standardized bioactive compounds, fostering agriculture healthcare partnerships and creating new revenue streams for farmers.

**Environmental and Economic Benefits**

**1. Waste Reduction:** Repurposing cucurbit vine residues avoids discarding or burning agricultural waste, reducing environmental impact and greenhouse gas emissions.

**2. Improved Soil Health:** Composting cucurbit residues enriches soil with organic matter, enhancing structure, moisture retention and nutrient availability, leading to healthier crops and less reliance on synthetic fertilizers.

**3. Circular Economy:** Utilizing agricultural by-products innovatively (e.g., bio-based materials, energy production) foster a circular economy, reducing demand for virgin resources and promoting sustainability.

**4. Reduction in Pesticide Use:** Creating natural pest repellents or bio-based materials from vine residues may reduce dependence on chemical pesticides, contributing to a cleaner environment and less harm to non-target species.

**Economic Benefits**

**1. New Revenue Streams:** Farmers can generate additional income from cucurbit residues by selling them for bioenergy, bio-based materials or animal feed.

**2. Job Creation and Industry Growth:** Processing cucurbit residues into sustainable packaging, bioplastics or fertilizers can create jobs and stimulate economic growth in rural areas.

**3. Cost Savings:** Converting residues into products like compost or biofuels reduces dependency on external inputs like chemical fertilizers and fuel, lowering operational costs.

**4. Market Expansion:** As demand for eco-friendly products grows, there is an opportunity for market expansion for bio-based products derived from cucurbit residues.

## Challenges and Limitations

### 1. Logistical Challenges

- **Collection and Transportation:** Gathering, transporting and processing vine residues can be costly and labor-intensive, especially for small farms. Vines are bulky and perishable, complicating storage and transportation.
- **Seasonal Availability:** Cucurbit residues are primarily available post-harvest, making supply inconsistent and complicating continuous processing or production.

### 2. Market and Economic Barriers

- **Limited Market Demand:** While demand for sustainable products is growing, the market for items derived from agricultural residues is still developing. Establishing a stable market requires consumer education, marketing and an accessible distribution network.
- **High Initial Investment:** Developing industries around cucurbit residues requires significant capital investment, which may be prohibitive for small-scale farmers or rural communities without government or private sector support.

### 3. Knowledge Gaps

- **Educational and Technical Barriers:** Many farmers may be unaware of potential uses for their cucurbit residues and limited access to technical support can hinder adoption. Collaboration among farmers, researchers, industries and policymakers is needed to develop practical solutions.

## Conclusion

Cucurbit vine residues offer a largely untapped opportunity to enhance agricultural sustainability and create economic value. Transforming these by-products into useful resources like compost, biofuels, bio-based materials and pharmaceuticals can reduce agricultural waste, lower environmental impact and diversify income streams. Overcoming logistical, technical and market challenges through continued research, investment and support from policymakers is crucial. Embracing innovative uses for cucurbit residues fosters a circular agricultural economy and promotes resilience, sustainability and growth in rural communities.

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# Jams of Different Fruits

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## Introduction

Jam is one of the most popular products consumed all over the world, everyone from children to adults use jam in breakfast or as a snack. For making jam, the fruit or its pulp is cooked with acid (sourness) and sugar for so long that the amount of sugar in the substance becomes at least 67-68 percent. It is preserved by sugar, because the growth of bacteria stops in such a thick consistency of sugar. It retains the true aroma and taste of the fruits. Although jam can be made from all fruits, good jam is made only from those fruits which have a sufficient amount of a substance called pectin, as it helps in setting the jam. If you want to make jam from a fruit with less pectin, then you should also mix with it a fruit in which pectin is present in sufficient quantity. Jam can be made by mixing one or many fruits. Jam made from a mixture of many fruits is called mixed fruit jam. The following is the process of making jam:

### Fruits suitable for making jam

Jam is made from fruits like mango, pineapple, apple, banana, pear, peach, apricot, plum, loquat, papaya, gooseberry, guava and strawberry etc. Jam is also made from carrots and tomatoes. In fruits where pectin is found in less quantity, jam can also be made by adding commercial pectin powder to them.

**Selection of fruits**

It is necessary that the fruit should be ripe at the right stage for making jam, because after being properly prepared, it gets full taste, sourness, sweetness and aroma. Overripe fruits should not be used in making jam, because after overripe, the pectin of the fruit turns into pectic acid. It is not necessary for making jam that the fruit should be big in size. Often fruits fall from the air or are chewed by birds. Such fruits can also be used for making jam, but it should be kept in mind that the stained or chewed part of the fruit should be completely removed while making jam.

**Preparation of fruits**

First of all, the fruit should be washed thoroughly, because various chemical substances are sprayed on the tree for the control of insects or diseases. Therefore, the fruit should be washed in a solution of about one percent hydrochloric acid and then washed in clean hot water. Now peel the fruit and cut it into two halves. But jam is made from gooseberry, strawberry and raspberry without peeling. The fruits are cut into small pieces or grated to make shreds.

**Cooking the fruits**

The pieces or pulp should be cooked in an aluminum or stainless steel pan with about one-fourth water so that the pieces are cooked well and the pulp is formed by crushing with a spoon. The work of crushing the pieces is easily done with a wooden spoon.

**Adding sugar**

Now sugar should be added to the pulp. Sugar is added according to the condition of the fruit. For sour fruits, 800-900 gm of sugar is added per kilogram of pulp, but for sweet fruits, 650-700 grams of sugar should be added per kilogram of pulp. After adding sugar, the jam should be kept for cooking and it should be stirred continuously with a spoon so that it does not stick to the bottom of the pan.

**Adding acid**

After cooking for a while, 4 to 6 grams of sourness should be added per kilogram of sugar added. Sourness is added in the form of citric or tartaric acid. Where these acids are not available, lemon juice can also be squeezed and added. The jam should be cooked on high heat so that it is prepared quickly, because the aroma of the fruit escapes and the taste of the jam deteriorate if it is cooked for a long time. It should be stirred continuously with a spoon otherwise there is a fear of its burning. Due to this, the smell of burning starts coming in the jam and its color also deteriorates. In large factories, jam is cooked with steam.

**Identification of jam being ready**

When it becomes quite thick while cooking, then the syrup starts coming out of it. But it should be kept stirring and its readiness should be identified by the following methods:

**(a) By thermometer:** Put a thermometer in the cooking jam. If its temperature reaches 105°C, then it should be considered ready.

**(b) By refractometer:** Dip a spoon in the cooking jam and drop a drop of jam on a plate and cool it. Apply it on the prism of the refractometer. If the amount of total soluble solids (Total Soluble Solids) is 68 degrees Brix on seeing, then the jam is ready.

**(c) By weight:** Usually the amount of jam is one and a half times the total amount of sugar added.

**(d) By sheet:** When dipping a spoon in the cooking jam and dropping the substance stuck in it, if a sheet-like formation starts forming at the bottom of the spoon, then the jam should be considered ready. With a little experience, the identification of making jam becomes known.

### Adding color

After the jam is ready, if necessary, dissolve a little food color in water and add it.

### Filling in bottles

Fill the hot jam in hot, clean bottles with wide mouths washed with boiling water. Wipe the bottles well with a damp cloth. To seal the jam, first pour hot wax on its upper surface after it has cooled down and then put on the lid and keep it in a cold and dry store.

On a commercial level, it is also filled in one pound jam-sized cans. The cans are sealed by machine. For example, the method of making apple jam is given in detail here.

### Apple Jam

**Ingredients:** Apple pulp 1 kilogram, sugar 750 grams to 800 gram approximately, citric acid 4 to 6 grams and edible color as much as needed to make the jam look attractive.

### Method of making

- Take sour varieties of apples for making jam. Rimer and Jonathan varieties are suitable for this.
- Wash the fruits thoroughly.
- Peel them with a stainless steel knife and cut them into two halves. Remove the hard part of the middle (core) with a core removing knife.
- Now cut the pieces into small pieces or grate them to make shreds.
- Take the pieces or shreds in an aluminum or stainless steel pan and cook with about one-fourth water.
- When they melt, crush them with a spoon and add sugar and sourness and cook again.
- Keep stirring it with a spoon so that it does not stick to the bottom of the pan.
- When it becomes quite thick while cooking, check its final point by the method mentioned above and add food color to it and take the pan off the heat.
- Fill the hot jam in hot, clean bottles washed with boiling water and dried with a wide mouth. While filling, keep in mind that air bubbles do not remain in the bottle.
- When it sets in the bottle, pour some hot wax on its upper surface to seal it and put on the lid and keep it in a dry and airy place.

### Jams of Other Fruits

The method of making jam from other fruits is also the same. The preparation of the fruit is different according to its structure. Here is the method of preparing some important fruits for making jam.

**(1) Pears:** After washing and peeling, cut the fruit into two parts and remove the seeds and core (the hard part of the seed). Then cut it into small pieces or grate it to make shreds. Make jam with the method mentioned in apple jam with the required amount of sugar and sourness.

There is another method of preparing apples and pears for making jam. Wash the fruits and remove the stalk part with a knife. Cut the fruits into small pieces without peeling. Now take the pieces in a pan, add about one-fourth water and cook for 30-40 minutes. The pieces will melt during this time. Mash them with a spoon to make a pulp. Now rub it through a sieve of aluminum or stainless steel to obtain a uniform (homogeneous) pulp. Thereafter, mix sugar and acid in the pulp as per requirement and make jam by the usual method. By rubbing the pulp in the sieve, the peel and the hard part of the middle (core) are separated and a sufficient amount of pectin also comes in the pulp, due to which good quality jam is made.

**(2) Peaches and Apricots:** Wash these fruits and remove the pit after cutting them from the middle. Now cut them into small pieces and make jam like the method mentioned for pears.

**(4) Mango:** Take pulpy mangoes like Dashehari and Langda for making jam. Peel the ripe fruit and scrape it with a knife to extract the pulp. Rub the pulp through an aluminum or steel sieve to obtain a uniform pulp. Now make jam from this pulp.

**(5) Strawberry:** This is a very delicate fruit and gets spoiled quickly if even a slight scratch is made or it is pressed. Therefore, arrangements should be made for making jam soon after picking the fruit from the tree. Remove the leaves and stalks of the fruit and wash them thoroughly. Due to being close to the ground, dust and dirt remain on its fruits, so it is necessary to wash them in running water. Crush the fruit with a spoon to make a pulp. For making strawberry jam, up to one and a quarter kilograms of sugar can be mixed per kilogram of fruit. This jam should not be filled hot in bottles immediately after it is ready, otherwise the pulp starts floating on top of the bottles. Therefore, when the temperature of the jam in the pan becomes about 65°C, it should be filled in the bottle.

**(6) Plum:** Wash these fruits and cook them in a little water to soften them. Now rub it through a sieve to obtain the pulp. By doing this, the seeds and peel will separate. Make jam from the pulp by the usual method.

**(7) Guava:** Take fresh, healthy and properly ripened fruits and wash them thoroughly. Remove the stalk part of them. Now cut the fruit into small pieces and cook with about equal amount of water in an aluminum pan. They will melt in about 30-35 minutes. Crush them with a spoon and rub through a sieve to obtain the pulp. In large factories, this work is done by a pulper. Make jam from the pulp as per the usual method.

**(8) Papaya:** For making jam, such papayas should be taken which are ripe but firm. Papaya is a fruit that is commonly grown in everyone's home garden. Therefore, its jam can be made at a cheap price. Wash the fruit and peel it. The green part of the peel should be completely removed. Cut it into two halves and remove the seeds and other unwanted parts. Cut it into small pieces or grate it to make shreds. Cook it with some water and crush it to make a pulp. Now make jam by the usual method.

**(9) Gooseberry:** Take healthy fruits and wash them. Boil them for 10 minutes and make halves and separate the seeds. Crush the halves with a spoon and filter through a sieve to obtain the pulp. By doing this, the fiber will separate. Now add sugar to the pulp and make jam by the usual method. It is very tasty and nutritious.

**(10) Ber:** Wash the fruits and scrape them with a knife to extract the pulp and separate the seeds. Cook the pulp in a little water and crush it with a spoon to make a pulp. Now make jam from this pulp by the usual method.

## Conclusion

Jam is a better option for preserving nutrients and aroma of fruits, because fruits are perishable in nature and difficult to keep fresh in a long time so we can make jam and other value added product to preserve the fruits flavor, vitamins and minerals.

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# Predicting Rainfall Through the Behavioural Patterns of the Indian Red-Wattled Lapwing

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## Introduction

The ability to forecast rainfall plays a critical role in agricultural planning, water resource management and disaster preparedness. While modern meteorological tools provide accurate weather predictions, traditional methods based on natural phenomena continue to hold value, especially in rural and agricultural communities. One such natural indicator that has garnered attention is the behavioural patterns of wildlife, particularly avian species. Among them, the Indian Red Wattled Lapwing (*Vanellus indicus*) offers a fascinating example of how animal behaviour can be linked to atmospheric changes, specifically the onset of rainfall.

**Overview of the Indian RedWattled Lapwing**

The Indian RedWattled Lapwing is a widely distributed wader bird native to the Indian subcontinent. Recognized for its striking black and white plumage, red facial wattles and distinctive call, this bird typically inhabits open fields, grasslands and agricul-tural areas. Known for its groundnesting behaviour, the lapwing lays its eggs in concealed areas within its habitat, where the eggs are camouflaged by vegetation or bare soil.

**Correlation Between Bird Behaviour and Weather Patterns**

Indian RedWattled Lapwing, are highly attuned to subtle changes in their environment, such as shifts in temperature, humidity and barometric pressure, all of which are precursors to rainfall. These environmental cues trigger specific behavioural responses, including alterations in nesting, feeding and activity patterns. The lapwing's reproductive cycle, in particular, offers a notable example of how animal behaviour is influenced by impending weather changes, making it a potential indicator of rainfall.

- **EggLaying and the Onset of the Monsoon:** A key behaviour observed in the Indian RedWattled Lapwing is the timing of its egglaying. This bird typically lays its eggs in the days leading up to the arrival of the monsoon rains. The increase in food availability, such as insects and vegetation, during the rainy season provides an optimal environment for the successful rearing of offspring. As a result, the lapwing's reproductive cycle is closely synchronized with the monsoon season and the timing of egglaying can serve as an indicator of the impending onset of rainfall.

- **Behavioural Changes Prior to Rainfall:** In addition to egglaying, the lapwing exhibits heightened activity and restlessness in the days leading up to rain. Changes in behaviour, such as increased foraging, altered roosting sites or more frequent vocalizations, may indicate the bird's sensitivity to changes in atmospheric conditions, such as a drop in barometric pressure or a rise in humidity, which typically precede rainfall. These behavioural shifts could, therefore, serve as early warning signals for approaching weather systems.
- **Sensitivity to Environmental Cues:** The Indian RedWattled Lapwing, like many other avian species, is finely tuned to its environment. The bird's ability to detect minute changes in temperature, pressure and humidity allows it to respond in ways that humans might not immediately perceive. The lapwing's instinctual behaviour, such as nesting or altering its activity patterns, provides insight into upcoming weather conditions, potentially offering an early indication of rainfall or storms.

### Practical Applications in Agriculture

In agricultural regions dependent on seasonal rainfall, the behaviour of the Indian RedWattled Lapwing can provide valuable information for farmers and rural communities. By observing the timing of egglaying and the bird's behavioural shifts, farmers can gain early insights into the timing of rainfall and adjust their agricu-ltural practices accordingly. For instance, the early laying of eggs by the lapwing may signal the approach of the monsoon, prompting farmers to plan sowing or irrigation schedules that align with the expected rainfall.

### Conclusion

While modern meteorology offers sophisticated techniques for predicting rainfall, traditional methods based on natural phenomena remain relevant, especially in regions where access to advanced weather technology may be limited. The Indian RedWattled Lapwing, with its sensitivity to atmospheric changes and synchronized reproductive behaviour, provides a unique and natural indicator of rainfall. By understanding and observing these behavioural patterns, there is potential to enhance weather forecasting and better align agricultural practices with seasonal weather events. The integration of both traditional ecological knowledge and modern meteorological data could lead to more resilient and informed agricultural practices, particularly in the face of unpredictable climate patterns.

### Reference


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# Indoor Gardening and Urban Landscape Planning

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## Introduction

Indoor gardening is the practice of growing plants in indoor or semi-outdoor spaces like homes, offices, balconies, terraces and patios, making it adaptable to various environments. It plays a crucial role in urban landscape planning, driven by increasing urban density, environmental awareness and the desire for sustainable living spaces. Popular forms of indoor gardening include container gardening, hydroponics, and vertical farming, each suited to specific needs. Indoor plants not only add aesthetic value but also help improve air quality and reduce pollution, enhancing the urban environment. India's garden culture, with roots dating back to 1200-1000 B.C., emphasizes blending aesthetics with functionality in landscape design. Urban planners and architects aim to bring nature into cities, addressing environmental and psychological challenges caused by urbanization. This field unites professionals like architects, landscape designers, and conservationists to create eco-friendly solutions, including the integration of natural elements like waterways. Additionally, modern urban planning incorporates smart grid technology to manage energy use in real time, reducing cities' carbon footprints and promoting sustainable energy systems. This technology allows for more efficient energy use, further contributing to eco-friendly and sustainable urban development.

### Urban landscape features

Urban landscape features focus on preserving, restoring and creating spaces like parks, wildlife refuges, recreational areas and nature centres. Additionally, they aim to protect watershed health, sustain forested and agricultural lands and promote safer drinking water.

### Indoor Gardening in Urban Environments

Indoor gardening involves cultivating plants within buildings, using soil, water or hydroponic systems. This practice has gained popularity due to its accessibility and benefits, which include air purification, stress reduction and improved aesthetics. Indoor plants can be as simple as potted houseplants or as sophisticated as green walls and vertical gardens.

### Benefits of Indoor Gardening

- **Air Quality Improvement:** Indoor plants absorb carbon dioxide and release oxygen. Plants like *Epipremnum aureum* (pothos), *Spathiphyllum* (peace lily) and *Dracaena* are effective at filtering toxins like benzene, formaldehyde and ammonia from the air (Wolverton, 1989).
- **Mental Health:** Research has shown that being around plants reduces stress, improves mood and enhances concentration and memory (Bringslimark *et. al.*, 2009).
- **Temperature and Humidity Control:** Indoor plants contribute to a natural humidifying effect, reducing the need for artificial climate control (Fjeld *et. al.*, 1998).

### Urban landscape Planning

Urban landscape planning involves designing and organizing open spaces, parks, streets and communal areas within cities to enhance liveability and ecological balance. It focuses on creating accessible green spaces that improve urban aesthetics, provide recreational areas and support biodiversity. Urban landscape planning relies on a thorough base plan, guiding the design process and addressing potential issues.

### The process includes six main steps

**1. Assessment of Needs and Capabilities:** Defines budget, area use, maintenance, labour, tools, soil and drainage needs, utilities, lighting and preferences for plants and materials.

**2. Site Survey:** Identifies existing structures (walls, sidewalks, water features) and topography, assessing drainage, soil conditions, vegetation and climate factors impacting plant choice.

**Fig 1: Physical Model Making for Landscape Design**

**Fig 2: Traditional hand-made physical model of the landscape design**

**3. Site Analysis:** Combines interview and survey data to evaluate problem and beneficial areas, often visualized through sketches.

**4. Pot Plan:** A scaled drawing showing lot layout, drainage and elevation details.

**5. Site Plan:** Updates the pot plan to include any new structures, topography changes and utility placements.

**6. Structures and Utility Blueprints:** Detailed plans showing utility placements and existing structure layouts, usually obtained from local authorities or original builders.

These steps help ensure a well-organized and effective urban landscape design.

### Key Components of Urban Landscape Planning

• **Green Roofs and Green Walls:** These installations provide insulation for buildings, reduce the urban heat island effect and improve air quality. Research has shown that green roofs can reduce building energy consumption by up to 30% (Liu & Minor, 2005).

• **Community Gardens and Urban Farmer**: Urban farms can reduce food deserts and provide access to fresh produce (Thibert, 2012).

• **Street Trees and Urban Forestry:** Street trees not only beautify neighbour hoods but also provide shade, reduce stormwater runoff and improve air quality (McPherson *et. al.*, 1997).

### Construction of Design for urban landscape

In urban landscape planning, the "construction of design" refers to the process of translating conceptual designs and master plans into physical urban spaces. This process is multi-faceted, combining ecological, social, aesthetic and fuctional elements to create sustainable, attractive and usable environments.

• The preliminary or draft designs in landscape construction help determine plant, tree and shrub placement, taking into account factors like climate, sun exposure, existing trees and surrounding structures. These designs bring the space to life by defining plant beds and layout. In urban design, there is an increased focus on creating accessible public spaces, including parks, plazas, bike lanes and pedestrian-friendly streets. By adding these spaces, urban planners can foster vibrant, nclusive communities, encouraging social interaction, physical activity and improved mental well-being for residents.

### Reconstruction of Design for urban landscape

Before beginning an urban landscape design project, designers must review restrictions from state and local governments, as well as from project owners. These restrictions cover aspects such as water usage, erosion control, aquatic vegetation and proximity to water sources. Element restrictions also specify the types of plants, trees, shrubs, soil and turf suitable for a particular area, ensuring compliance with environmental and zoning standards. There are also rules about distance to water sources and how land around a body of water can be used or changed. Another aspect of landscape design is element restrictions. Element restrictions identify the type of plants, trees, shrubs, soil, turf and grass that should be used in a specific locale.

### Site Analysis and Contextual Research

Before construction, urban landscape planners conduct a thorough site analysis to understand the physical, environmental, social and cultural context. This research includes:

• Topography, Soil and Climate.
• Ecological Assessment.
• Social and Cultural Factors

### Conceptual Design and Master Planning

In this phase, planners translate research findings into conceptual designs that outline spatial arrangements, green spaces, circulation paths and potential structures. Key considerations include:

• **Spatial Organization:** Mapping out functional zones like recreational areas, pedestrian walkways, green spaces and urban plazas. The layout should balance public access and ecological needs, ensuring users have functional and pleasant spaces.

• **Green Infrastructure:** Planning for green roofs, rain gardens, urban forests and bio-swales. These features help mitigate urban heat, control stormwater and support biodiversity.

• **Circulation and Connectivity:** Designing pathways, bike lanes and public transit routes that connect urban spaces, improve mobility and promote active lifestyles.

**Implementation of Technological Tools**

Advanced technology assists in designing, constructing and maintaining urban landscapes.

• **GIS and 3D Modeling:** Geographic Information Systems (GIS) help planners analyze spatial data, while 3D modeling offers visual previews, enhancing precision and stakeholder understanding.

• **IoT in Landscape Management:** Smart sensors can monitor soil moisture, air quality and weather data, supporting efficient irrigation and reducing resource waste.

• **Sustainable Lighting and Irrigation:** Solar-powered lighting and drip irrigation reduce energy and water consumption while maintaining safety and plant health.

**Maintenance Planning and Community Engagement**

Long-term sustainability relies on effective maintenance and active community involvement.

• **Maintenance Plans:** Urban landscapes require ongoing care, including plant pruning, waste management and pathway repair. Efficient maintenance plans reduce costs and enhance durability.

• **Community Participation:** Involving local residents in community gardens, clean-up days, and urban greening projects fosters a sense of ownership, ensuring landscapes remain vibrant and well-kept.

• **Adaptive Management:** Maintenance teams monitor landscape health and adapt practices to address emerging issues, such as invasive species, pest outbreaks or climate change impacts.

**Challenges Facing Urban Designers in landscape planning**

Urban designer's face several key challenges as cities evolve, including:

**1. Affordability:** Rising urban living costs make affordable housing and accessible public spaces essential.

**2. Equity:** Designers must address disparities, ensuring equal access to services and amenities across communities.

**3. Climate Change:** Cities need resilience against climate impacts like extreme weather, requiring sustainable infrastructure and green spaces.

**4. Infrastructure:** Aging infrastructure needs upgrades for safety, efficiency and collaboration with municipal agencies.

**5. Transportation:** Creating integrated, sustainable transit systems improves mobility, air quality and connectivity.

**6. Health and Wellness:** Urban environments should promote physical and mental health through green spaces and walkability.

**7. Safety and Security:** Public spaces must be designed to ensure visibility, accessibility and safe environments.

**8. Heritage and Culture:** Preserving cultural heritage fosters a sense of identity and community.

**9. Governance and Public Participation:** Collaboration among government, businesses and residents is vital for responsive design.

**10. Community Engagement:** Designers must involve diverse stakeholders to reflect community needs and build trust. Though complex, these challenges also present opportunities for innovative, sustainable and inclusive urban design that fosters resilience and enhances urban life.

## Challenges and Future Directions

Despite the benefits, integrating indoor gardening and urban landscape planning faces challenges, including:

- Cost and Maintenance
- Space Constraints
- Climate Suitability & Future strategies

## Conclusion

Urban landscapes now focus on preserving natural resources while fostering spaces for humans and wildlife. Beyond growing food, urban gardening strengthens communities, raises property values, improves health and enhances sustainability. As cities expand, integrating green spaces like community gardens becomes crucial for creating more liveable, resilient and inclusive environments. By blending nature into urban settings, these landscapes beautify surroundings, support wildlife and promote a healthier environment for future generations, an essential goal in times of global change.

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# Prospects of Persimmon Cultivation in Uttarakhand: A Sustainable Horticultural Opportunity

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## Introduction

Persimmon (*Diospyros kaki*) belongs to the family Ebenaceae of order Ericales. A deciduous fruiting tree originates in China and is intensively cultivated in Japan. It is widespread in China, Korea, Japan, Italy, Israel, Australia and India. It is a popular fruit known as Japanese persimmon and is worldwide relished for its unique taste. In India, it is called *Japani Phal* and in Uttarakhand, it is locally called Kaku or *Ramphal*. It was introduced by Captain A. N. Lee in Kullu Valley in 1921 and is grown in semi-commercial scale in different parts of India. Persimmon is also gaining popularity in India but is still cultivated in small pockets of Himachal Pradesh, J&K, Nilgiri Hills and some parts of Uttarakhand (district Nainital). In Uttarakhand, Persimmon is in a very nascent stage; it is growing in small pockets of Bhowali, Ramgarh and Mukteshwar and some incentives are recently starting in the region of Tehri Garhwal, but these lack proper intensification.

It is distributed across the tropical and warm temperate regions of the world. Japanese persimmons (*Diospyros kaki*) is a hexaploid tree having chromosome no. 2n=6x=90 (Jain *et. al.*, 2023). There are 141 cultivars that consist of 110 native Korean and 31 Japanese cultivars that are grouped into astringent type and non-astringent type further sub-grouped into pollination variant and pollination constant type. Both types differ in tannin content, the non-astringent type is ready to eat after harvest while the astringent type cannot be eaten immediately after harvest; it takes some time to lose its astringency for the conversion of tannins into starch which makes it sweeter like honey in taste. But it cannot be consumed if the tannins content is more than 0.5%. Astringent Cultivars include Hachiya, Fuji, Nightingale, Flat Seedless, Triumph, Hyakuma and Saijio, while non-astringent cultivars include Fuyu, Wase Fuyu, Hana Fuyu, 20th Century, Suruga and Jiro, also known as perfect sweet persimmons, pollination constant and non-astringent (PCNA).

**Nutritional Importance of Persimmon**

Persimmon is very well known for its nutritional value and is also used to treat many diseases in Japanese medicine like cardiovascular disease, anti diabetic effects, anticancer effects, stroke, anti-aging effects and post-traumatic epilepsy (Redpath and George, 2008). Bright orange-reddish fruits are a good source of ß-carotene, 250 μg/100 g in ripened fruits with peel and 190 μg/ 100 g in fruits without peel. It is full of nutrients such as proteins (0.58%), lipids (0.19%), total carbohydrate (18.6%), vitamins, minerals (potassium, magnesium, zinc, iron, copper, manganese) and organic acids (Ozen *et.al.*, 2004). Furthermore, persimmons have a great amount of functional compounds like fibre (0.69%), ascorbic acid (15.90 mg/100g), β-carotene (250 mg/100g) and total phenols (3.87 mg/100g). These are responsible for high anti-oxidation properties of the fruit. These benefits can be utilized to make new functional food products.

**Agro-Climatic Suitability of Uttarakhand for Persimmon**

Persimmon grows well in warm temperate areas. Uttarakhand has a total geographical area of 5.35 million ha of which 86% is a hilly region. The area of Uttarakhand can be divided into 4 zones: A, B, C and D based on Agro-climatic conditions, slopes and height. The area falling under zone B (mid-hills 1000-1500m) is most suited for persimmon cultivation. However, certain parts of Zone A (600m-1000m) and Zone C (1500m -2500m ) can also be undertaken for the successful cultivation of persimmon due to the existing agro climatic conditions. On average, its plant thrives in areas that are 500 to 2000 m above sea level. The ideal temperature is between 10ºC to 30ºC. To break plant dormancy, it also requires 800 chilling hours at 8-11ºC but plants need to be protected from extreme heat and also extreme cold temperatures. Frost can harm newly emerged flower buds and fruits which can cause loss in total yield. Astringent types are more tolerant to cold weather and can withstand temperatures as low as -25ºC, while sweet varieties (Non–astringent) cannot tolerate temperatures below -15ºC. Light Loam soil with a pH range of 5.5 to 6.5 is optimal for plant growth.

**Species, Commercial Varieties and Rootstocks**

Among the important fruit-bearing species, *Diospyros virginiana* from North America, *Diospyros lotus* L. and *Diospyros kaki* L. from China are renowned as the finest edible species. In India, related species include *Diospyros tomentosa* (tendu), *Diospyros lotus* (Amlok) and in southern regions, *Diospyros discolour*, *Diospyros embryopteris* and *Diospyros melanoxylon,* which produces coromandal ebony wood. In India, Fuyu, Hachiya, Jiro, Triumph and Saijo are famous cultivars used in commercial orchards. Among all, Fuyu is the most popular non-astringent cultivar; it lacks seeds, pumpkin-orange in colour and has a rich crisp texture. Hachiya has an acorn form; it's an astringent cultivar when it is fully ripened, it becomes even sweeter than non-astringent cultivars like Fuyu. Jiro is non-astringent cultivar pollination constant. It can tolerate low temperatures suitable for high hills. Triumph is a famous cultivar from Israel; it has a low chilling requirement. It is a pollination constant astringent cultivar.

*Diospyros kaki* and *Diospyros virginiana* are commonly used as rootstocks for oriental persimmon in Israel and the USA. **Diospyros virginiana** is especially suited to damp, heavy soils and is cold-hardy. However, Diospyros kaki is generally preferred over *Diospyros lotus* and *Diospyros virginiana* as a rootstock for persimmon.

### Propagation

Grafted plants are used for commercial production of persimmon which ensures better yield. Whip and tongue grafting is used for thinner plants while wedge grafting is for thicker seedlings. For propagation, *Diospyros lotus*, a wild persimmon variety (Amlokh) with good resistance against low winter temperatures and water scarcity is used as rootstock. It is propagated with the help of seed generally or sometimes cuttings.

Seed is collected from ripe fruit separated from its flesh, then dried and layered in moist soil for stratification. Seeding can be done in winter under a polyhouse or at the end of the winter season when temperatures are higher (night temperature does not fall below 5ºC, spring season). Seeding is done directly into the nursery at a spacing of 20 cm plant to plant and 100 cm between rows. Soft soil (1/2 s and, 1/2 soil) of the nursery is preferred, ensuring less damage to the root system while uprooting (***E. Bellini***). The use of mycorrhiza promotes good root development in young seedlings. In addition, it increases height and no. of leaves. The fungus increases concentration of Phosphorus in the principal and lateral roots of all inoculated plants (Matsubara and Hosokawa, 1999). Direct sun exposure is also taken care of because young seedlings are very sensitive to burning damage. After a year, the plant is ready for grafting. Scion is taken from healthy and well-lignified plants during dormancy (scion, diameter 6 mm to 10 mm) and kept under refrigeration until the time of grafting or immediately grafted on rootstock about 20 cm from the collar (***E. billin***).

### Plantation

Spacing depends upon various factors; cultivar vigour, soil fertility and training system used. In general, 5 × 5m is preferred. In shallow or poorly fertile soils, cultivars show less vigour, thus spacing 4.5 × 4.5m is preferred. Hachiya, a vigorous cultivar in good fertile soil with deep soil at times requires 7 × 7m to avoid intermingling of branches and in Fuyu, 5-6 × 5-6m spacing according to soil depth and fertility. Attempts at high-density plantations 3 × 4.5m are also made which develop the early formation of fruitifying walls and early productivity of orchards. In winter, the ideal time for the plantation starts from early December to the second fortnight of February. Delay in plantations reduces the chances of plant survival. Persimmon faces difficulties in rooting and suffers dehydration after transplanting. The roots of dormant plants uprooted for transplanting are soaked in dung to enhance survivability (Bellini, 2002). Mulching and drip irrigation improve the moisture conditions of the soil which increases the survivability of pants.

### Nutrient management

Persimmon is a less demanding tree compared to other temperate fruiting trees due to its deep rooting system and active water absorption. In Uttarakhand, mount-ains are soil-less fertile, shallow and rocky which can create problems of alternate bearing and poor yield as trees mature. Thus, maintaining soil fertility becomes more important. The nutritional needs of plants vary with their vegetative and productive phases; sprouting, growth of buds and leaves, flowering, fruit set, fruit development and dormancy. The Bud development phase is critical in persimmon and requires sufficient nutrients to produce a good yield. But due to deep spreading roots and slowly developing roots, their response is slow towards fertilizer application. Thus, a limited application of manure, slow-releasing nitrogen, together with phosphorus and potassium applied at the beginning of autumn is effective for the final fruit growth phase and accumulation of nutritional reserve for the initial vegetative growth of the next season and the second application is done at the end of winter. A good level of phosphorus increases average fruit weight and enhances color development appealing to the market. It is advised that soil testing is done for better fertilizer recommendations which are easily done under the soil health card scheme provided by the government of India by reaching any nearby KVKs, Horticulture department.

A fertilizer mixture containing 4-6% nitrogen (N), 8-10% phosphorus (P) and 3-6% potassium (K) has shown good results when applied at a rate of 500g per tree per year of age. While it is typically applied in spring, some growers prefer to split the dose, applying half in spring and the remaining half in July.

## Irrigation

Persimmons are deep-rooted trees but roots develop slowly. For newly transplan-ted plants, irrigation is important to prevent plants from dehydration so frequent water is needed 2 to 4 times a week. During spring and summer, there is a large amount of vegetative growth to sustain this watering once or twice a week is necessary. It becomes tolerant to water scarcity as its tree matures. Water becomes crucial for fruit set and fruit development so irrigation is needed if there is less rainfall. For good water and nutrient management, installati-on of drip irrigation systems is highly beneficial. Uttarakhand horticulture depar-tment provides an 80% subsidy for drip installation in orchards.

Training and Pruning.

Normally in Japan, either persimmon plants are allowed to grow in a natural way i.e., in the central leader system, or they are slightly pruned and trained in a modified leader system, which is convenient for cultural operation and ensures better light penetration in structure. A tree with a central leader will grow straight and has no inward shoots because light does not penetrate inside. To overcome this, tall central leader is headed back to allow sunlight penetration inside the structure, which is known as a modified central leader. The first primary scaffold branch should be 50-60 cm above the ground. Primary scaffold branches should be forced to grow at a crotch angle of 45$^{o}$. Secondary scaffold branches are grown horizontally and should not be allowed to overlap with any other branches. Winter pruning is done to reduce the number of shoot sprouts. Appropriate winter pruning maintains the tree's vigour. The main objective of winter pruning is to increase the number of fruit-bearing shoots. Fruit thinning is also done for quality fruits and big-size fruits, done after 30 days of anthesis. NAA @10 ppm spray is applied three days after the full bloom stage, for fruit thinning.

## Pollination and Fruit Set

Persimmon flowers can be female, male, or hermaphrodite. However, species can be monoecious, dioecious and polygamousdioecious. Commercially, female flowers that produce seedless fruits are preferred. Persimmon experiences heavy fruit drop after 25-30 days of fruit setting which is the major limiting factor of production. Fruit drop can be related to lack of pollination, insufficient sunlight, excessive vegetative growth, etc. Studies have shown that pollination is also important for the varieties that produce fruit through parthenocarpy to reduce the fruit drop. When *Diospyros virginiana* or Kandaghat pink is used as a pollinator, it reduces fruit drops and no fruit drops occur after 90 days of fruit set. Also, an increase in fruit size and weight was observed (Chauhan *et. al*., 2017). Appropriate pollinizers (wild varieties), interplanting, manual pollination and insect pollination by bees (2 bee hives/ha) are some significant majors in reducing fruit drop. The application of growth regulators like GA (15-30 ppm) is another option to reduce fruit drops.

**Pests and Diseases**

Persimmon is a hardy plant that is less susceptible to disease as compared to other temperate fruit crops. But some diseases often faced by the farmer are Crown Gall which is caused by bacteria that enter through wounds and injuries, Cercospora leaf spot caused by fungus and bitter rot. Some insects also cause damage to the crop like scale insects and sap-sucking insects, but due to their fewer occurrences, farmers prefer biological control over chemicals like the use of neem oil. Farmers face problems related to damage by birds and animals. Therefore, nets are used to protect fruits from birds and animals (monkeys) damage. The government also provides subsidies in hill areas for installation of fences and hail nets.

**Maturity indices, Harvesting and Post harvest Management**

Persimmon fruits are harvested when they have attained yellow to reddish colour but are still firm. Brix level at maturity in different varieties varies between 14-17° Brix. The fruits are clipped from the trees with shears leaving the calyx attached to the fruit together with a short stem. Fruits are available for harvest from September to October when fruits are orangish-red in colour. If fruits are harvested too early, they develop poor colour, sweetness and flavour. Fully mature trees produce 100-200 kg of fruits per year. Growth regulators like GA3 are also used to delay fruit growth, chlorophyll degradation and carotenoid development for delayed harvesting, better firmness, good storability and better quality persimmon.

Skin colour is a good parameter for predicting shelf life. Partially green fruits can be stored for longer durations but fruit taste quality is compromised. Persimmons can be stored only for two to three months in cold storage (0°C-2°C and with RH 85-90%) because of the problems of cold damage and mould caused by *Alternaria alternata*. Astringent and late-ripening ones are less susceptible to storage damage. The colour of persimmon gradually evolves during storage and sometimes it can become brownish, a sign of cold damage (Gorini and Testoni, 1988). In Japan and China, persimmon is peeled and hung by rope for sun drying, for making dried persimmon, which is a well-known product. Persimmon is rich in sugar (16-20%), which makes it ideal for jam-making. In Japan, it is also used for making alcoholic drinks. Persimmon fruits are mainly graded for size. Persimmons are packed in corrugated cardboard, whereas a single-layer box is used for best-grade and two and three-layer boxes for inferior ones.

**Government Policies and Subsidies**

The Mission for Integrated Development of Horticulture (MIDH) and state horticulture boards are promoting and supporting farmers to start their horticultu-re project. Uttarakhand horticulture board provides various subsidies for orchard establishm-ent, fencing, drip irrigation, implements, etc., providing 50%-80% subsidies.

## Future Directions and Recommen-dations

India has a wide variety of climatic conditions but due to the availability of a few (Hachiya, Fuyu, Hyakume and Jiro) varieties, it is restricted to a limited area .Therefore, introduction of new cultivars from abroad will facilitate farmers. Varietal improvement, strengthening of research and training of farmers on advanced production technologies are the needs of the present.

## Conclusion

Persimmon cultivation holds significant promise as a sustainable horticultural opportunity in Uttarakhand. With its adaptability to diverse climatic conditions, including the region's temperate and subtr-opical zones, persimmon offers farmers a resilient crop option. Its nutritional value, high market demand, and potential for value-added products like dried fruits and juices further enhance its economic viability. Moreover, the cultivation of persimmons aligns with sustainable agricultural practices due to its low water requirement and minimal need for chemical inputs. By promoting persimmon cultivation, Uttarakhand can not only diversify its agricultural portfolio but also contribute to environmental conservation and economic growth in the region. Thus, investing in persimmon cultivation stands poised to yield long-term benefits for both farmers and the state's agricultural sector.

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# Prospects of Apple Farming in Lower Himachal Pradesh

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## Introduction

Apple farming is an important activity & livelihood of farmers in the Himalayan states of India. Apple cultivation in Himachal Pradesh is started in 19th century and initially established in Bundrole village of Kullu districtby Capt. R.C. Lee. The apple fruit occupied only 10 percent area from 134 ha of the total area under fruits in 1955, which was confined to a few pockets namely Mahasu, Kullu and Mandi etc. from where it diffused to other parts of the state. The total area under apple in Himachal Pradesh is about 112634 ha with a production of 446570 MT (NHB, 2018). Apple farming is the fastest growing economic activity of the state and is being grown in 9 districts out of 12 districts. Earlier in Himachal Pradesh the apple farming is concentrated in the higher altitude with an elevation of 2500-3500 meters above mean sea level due to traditional and high chilling requirement varieties. Earlier it was confined only in Kullu, Kinnaur, Shimla, Lahual & Spiti and some higher regions of Sirmour and Mandi district because of non-availability of low chilling varieties.

The Climatic conditions of Himachal Pradesh is so ideal for producing a wide variety of fruits hence almost every district of state specialized in the producing a particular crop. Similarly, apple farming is not only restricted in higher elevation or upper region of Himachal Pradesh but also in lower region e.g. Kangra, Bilaspur, Hamirpur, Solan and Una districts because of availability of low chilling varieties that is require only 200-300 chilling hours. Earlier lower district of Himachal Pradesh is known for growing of tropical and sub-tropical fruits like mango, litchi and citrus but from last 10-15 year's apple farming is flourishing day by day and the Kangra valley has become a leading producer of apple among the lower elevation districts. The revolution of apple farming in lower districts is only possible due to hardwork of fruit Scientists, Extension worker and progressive farmers. It has become possible after introduction of low chilling apple varieties from Israel e.g. Anna and Dorsett Golden and one variety namely Hariman or HRMN 99 developed by a farmer of Bilaspur district of Himachal Pradesh.

**Anna:** This variety was bred in Israel in 1950's. It requires less than 300 chilling hours and can therefore be planted in all low hill areas of Himachal Pradesh. The fruits look somewhat like fruits of Golden Delicious variety.

**Dorsett Golden:** This variety was bred by Mrs Dorsett of Bahamas. It also looks like Golden Delicious. This variety also requires less than 300 hours of chilling and is bearing fruits at many places in HP.

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**Table no. 1 District wise change in Area and production of Apple in Himachal Pradesh 2009-10 to 2017-18**

| Sr. No. | District | 2009-10 | | 2017-18 | |
|---|---|---|---|---|---|
| | | Area (ha) | Production (tonnes) | Area (ha) | Production (tonnes) |
| 1 | Chamba | 11,490 | 3,962 | 12,594 | 12,688 |
| 2 | Kangra | 450 | 401 | 455 | 298 |
| 3 | Kinnaur | 9,838 | 40,289 | 11,179 | 61,673 |
| 4 | Kullu | 23,870 | 54,385 | 26,794 | 76,019 |
| 5 | Lahaul and Spiti | 9,59 | 1,93 | 1,702 | 3,02 |
| 6 | Mandi | 15,531 | 8,659 | 16,638 | 43,968 |
| 7 | Shimla | 33,579 | 1,71,945 | 40,566 | 1,69,962 |
| 8 | Solan | 95 | 28 | 42 | 17 |
| 9 | Sirmour | 3,248 | 2,42 | 2,579 | 3,670 |
| 10 | Una | 0 | 0 | 3 | 0 |
| 11 | Bilaspur | 4 | 1 | 21 | 4 |
| 12 | Hamirpur | 0 | 0 | 61 | 2 |
| | Himachal Pradesh | 99,564 | 2,80,105 | 1,12,634 | 3,68,603 |

**Source:** Directorate of Horticulture, Govt., of Himachal Pradesh Shimla & H.P. Statistical abstract of Himachal Pradesh 2018-19

**Anna variety of Apple**

**Dorsett Golden variety of Apple**

**Hariman or HRMN 99:** This is a wonder apple which can grow even in the plains. It was developed by Hariman Sharma, a farmer from district Bilaspur. It was a chance seedling noticed by Hariman, who multiplied it further. It is a very early variety. The fruits ripe in the month of June. Hariman fruits, however, have a short shelf life and have to be sold in 8-10 days. Trees of this variety have been planted and fruiting occurs successfully at many places outside Himachal, including Rashtrapati Bhavan, Delhi. Hariman is self-fruitful and does not require any polliniser. However, in case of Anna and Dorsett Golden the fruit setis said to be improved if trees of both varieties are planted together.

Many farmers of Kangra valley started growing low chilling varieties like Anna & Dorsett Golden. Apple is grown almost every block in the Kangra district and some farmers cultivate more than one hectare of apple. Currently the apple harvest provides substantial revenue for the apple growing farmers because the apple of lower region arrives in the market in the month of June and that time there is no apple at all expected from cold stores.

Apple farming in lower district becoming popular day by day. If we compare area and production data of present and one decade earlier then there is clear-cut picture which shows the interest of farmers towards apple farming. The area under apple farming in Kangra district had increased 5 ha in last 10 yearsbut as compare to Kangra, Bilaspur and Hamirpur district showed a good progress in case of area under apple cultivation (Table 1). Hamirpur had 0 ha in the year 2009-10 but in 2017-18 it reached 61 hectares similarly Bilaspur had only four ha in 2009-10 and now it increased to 21 ha in the last decade (Table 1).

depicts that there are not much changes in apple production in lower districts of Himachal Pradesh, even in Kangra district apple production in 2017-18 (298 tonnes) is less than 2009-10 (401 tonnes). Earlier in Kangra district most of the apple cultivation was limited to Bara & Chota Bhangal area of Baijnath block where high chilling varieties were grown but from the last few years'apple cultivation also started in foot hills of Dhauladhar range. Most of the apple plantation in lower districts like Kangra, Una, Hamirpur and Bilaspur are under juvenile phase which is another major cause behind low production.

## Advantages of apple farming in lower region

**1. Early Harvest:** Apple of lower Himachal come in the market in the month of June and that time there is very less or no availability of apple.

**2. Good Income:** Apple of lower region comes very early as compare to upper region hence there is very less apple supply to the market and demand is high so farmers fetch a good income i.e. Rs. 150-200/kg.

**3. Short Juvenile Phase:** Anna and Dorsett Golden come into bearing after 2$^{nd}$ to 3$^{rd}$ of planting and give full harvest at an age of 6-7 year after transplanting.

**4. Less Scab:** These varieties are less prone to scab disease due to good climatic conditions prevailing right from flowering to harvest.

## Disadvantages of apple farming in lower region

**1. Low self-life:** Low chilling varieties have poor self- life (8-10 days in normal condition) due to high water content hence it's not beneficial to it keep them for long duration.

**2. Canker Problem:** Low region apple plantations have very high risk of canker disease due to high temperature and direct sun light. Direct sun light and high temperature burn the outer bark of plant and skin of plant become dead which cause canker.

**3. Marketing problem:** Marketing is the challenge for apple growers because they have very less produce and hence they have to sell in the nearby market only. They fail to send it to big markets.

**4. Less Price:** Low chilling varieties fetch low price as compare to other varieties due to their taste, shape, size and colour.

## Conclusion

Apple is known in Himachal Pradesh as a most significant commercial fruit crop. Apple cultivation is considered to best way to utilization of the natural sources of the hills which gives more remuneration than the field crops and generates more income and employment and thus resulted in the shift of farming from field crops to horticultural crops especially apple. Apple farming in lower districts may fulfill the requirement or demand of neighboring state as these districts are nearer to neighboring state. In future research may be targeted towards breeding good quality apple varieties for lower elevated areas so that farmers of these areas can be benefited.

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# "Securing the Future of Farming: The Critical Role of Cybersecurity in Agriculture"

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## Introduction

In the digital age, agriculture is no longer limited to traditional farming methods. The integration of technology has revolutionized the sector, introducing smart farming practices, automated systems and data-driven decision-making. However, this digitization comes with significant vulnerabilities. Cybersecurity has become a critical aspect of ensuring the smooth operation of modern agriculture, protecting it from various cyber threats. Here's an in-depth explanation of why cybersecurity is essential for the agriculture sector.


### Increasing Dependence on Technology

Modern agriculture heavily relies on digital technologies such as:

- **IoT Devices:** Sensors for monitoring soil conditions, water usage and crop health.
- **AI and Machine Learning:** For predictive analytics to optimize yields and manage pests.
- **Automation and Robotics:** Automated tractors, drones and irrigation systems.

The growing interconnectivity of these technologies creates vulnerabilities. A cyberattack could compromise these systems, leading to operational disruptions and financial losses. For instance, hacking an irrigation system could result in overwatering or drying out fields, impacting crop health and yields.

### Threats to Supply Chains

Agricultural supply chains are increasingly digitized for logistics, inventory management and quality control. Cyberattacks

targeting supply chains can
• Delay the transportation of perishable goods.
• Disrupt inventory tracking, causing shortages or surpluses.
• Compromise food safety standards, impacting consumer trust.

A ransomware attack on a logistics company, for example, could paralyze the movement of goods, affecting both farmers and consumers.

**Data Protection and Privacy**

Agriculture now generates massive amounts of data, including
• Yield forecasts.
• Soil and weather conditions.
• Market trends.

This data is critical for precision agriculture and strategic planning. A breach could result in stolen proprietary data or manipulation of sensitive information, giving competitors an unfair advantage or misleading farmers into poor decisions.

**Economic Implications**

Cyberattacks on agriculture can have severe economic consequences:
• **For Farmers:** Financial losses due to disrupted operations, reduced yields, or ransom payments.
• **For Governments:** Increased costs for mitigating attacks and ensuring food security.
• **For Consumers:** Higher prices due to reduced supply or inefficiencies in the supply chain.

According to a study by the U.S. Department of Agriculture, the agriculture sector contributes significantly to GDP, making its cybersecurity a matter of national economic interest.

**National Security and Food Safety**

Agriculture is a critical sector for national security as it directly impacts food availability. Cyber threats targeting:
• **Livestock Databases:** Could introduce false information, leading to health scares or disrupted meat production.
• **Crop Management Systems:** Could manipulate pesticide applications or irrigation schedules, resulting in contaminated or unusable produce.

Bioterrorism, facilitated by cyberattacks, is a growing concern. Hackers could target food processing systems to introduce harmful substances, posing threats to public health.

**Emerging Threats in Smart Farming**

Smart farming technologies like drones, automated systems and cloud-based platforms are particularly vulnerable to:
• **Unauthorized Access:** Hackers taking control of drones or robots could disrupt farming operations.
• **Data Manipulation:** Altering sensor data to mislead farmers about crop health or soil conditions.
• **System Downtime:** Distributed Denial of Service (DDoS) attacks could shut down critical systems during planting or harvesting seasons.

**Human Error and Insider Threats**

Despite advanced technologies, human factors remain a significant vulnerability
• **Phishing Attacks:** Farmers or staff may fall victim to phishing emails, granting attackers access to critical systems.
• **Weak Passwords:** Poor password practices can lead to unauthorized access to systems.
• **Insider Threats:** Disgruntled employees with access to sensitive systems can cause significant harm.

Addressing these issues requires both technological solutions and awareness programs for stakeholders.

**Impact of Climate Change and Increased Vulnerabilities**

Climate change has forced the agriculture

sector to adopt adaptive technologies, such as climate-resilient crops and predictive weather analytics. These systems, often powered by cloud computing and IoT, are attractive targets for cybercriminals. Disrupting these technologies could hinder farmers' ability to adapt to changing climatic conditions, exacerbating food insecurity.

**Compliance with Global Regulations**

As governments implement stricter data protection laws, the agriculture sector must adhere to these regulations. For instance:

• The European Union's General Data Protection Regulation (GDPR) mandates data privacy and security.

• The U.S. Food Safety Modernization Act (FSMA) requires measures to ensure the integrity of food supply chains.

Non-compliance could lead to legal penalties, loss of business and reputational damage.

**Mitigation Strategies and Solutions**

To address cybersecurity challenges, the agriculture sector must adopt a comprehensive approach

• **Robust Cybersecurity Frameworks:** Implement firewalls, intrusion detection systems and encryption for sensitive data.

• Regular Software Updates: Ensure that all systems are updated to mitigate vulnerabilities.

• **AI-Driven Security:** Use machine learning to detect anomalies and prevent attacks proactively.

• **Blockchain for Traceability:** Enhance supply chain transparency and security using blockchain technology.

• **Cybersecurity Training:** Educate farmers and staff about recognizing threats and best practices for cybersecurity.

• **Incident Response Plans:** Develop contingency plans to minimize downtime during cyberattacks.

**Conclusion**

Cybersecurity is no longer optional for the agriculture sector. As technology continues to transform farming practices, securing digital systems becomes essential to ensure operational efficiency, economic stability and national food security. By proactively addressing cyber threats, the agriculture sector can not only safeguard its operations but also build a resilient and sustainable future.

For further reading, explore research papers, government reports and cybersecurity guidelines specific to the agriculture sector.

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# Intellectual Property Rights in Plant Breeding

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## Introduction

In plant breeding, two types of intellectual property rights (IPRs) play a major role; plant breeders' rights (PBRs) and patent rights. IPRs constitutes a contract between the "inventor" and society. The IPR holder obtains the exclusive right to market the invented product for a defined period of time (usually 20-30 years), allowing him to realize returns on his investments. Plant breeders regard the use of IPRs as a fair mechanism to regain their investments and as a prerequisite for continued investments in plant breeding. It provides the strongest protection for plant breeders, granting the holder the exclusive right to reproduce and market the protected variety.

**Plant breeder's right (PBR)**

It is granted by a government to the breeder or originator of a variety.

The rights empower the breeder to exclude others from producing or commercializing the propagating material of the protected variety for a period of at least 15-20 years.

A person holding the PBR title to a variety can authorize other party parties to produce or sell the propagating material of that variety.

He is expected to set reasonable terms for the transfer of PBR title or for the sale of the propagating materials, otherwise the government can grant license of the right in the public interest.

In PBR, the variety is the subject of protection.

**Need of plant breeders right**

1. It encourages breeders by providing economic incentives.
2. It encourages private sector to invest in plant breeding activities.
3. The development of a variety is an innovation. Therefore a plant variety is an intellectual property, which should be protected.

**Basic requirements of plant breeder right**

As per the provision of UPOV Act (1991), a plant variety must satisfy the following criteria for protection

**Novelty:** The variety must not have been exploited commercially for more than one year before granting of PBR protection.

**Distinctiveness:** The new variety must be distinguished from other varieties by one or more identifiable morphological, physiological and other characteristics.

**Uniformity:** The variety must be uniform in appearance under the specified environment of its adaption.

**Stability:** The variety must be stable in appearance and its claimed characteristics over generation under the specified environments.

**Protection of plant breeders' right**

The UPOV Act (1991) offers the following protections to variety developed by plant breeder.

- Production for commercial purpose, offering for sale and selling all material of the protected variety is the exclusive right of the holder of PBR title.
- A grower may be allowed to use a part of his harvest for planting his next crop without any obligation of the breeder.
- Exchange of propagation material of protected cultivars between farmers is not allowed.
- The minimum period of protection is 20 years.

Some UPOV member states provide protection for up to 25 years or even 30 years (Maize in France).

**Farmer's rights act, 2001**

The Act recognizes the farmer's rights in the following respects.

- Registration of farmer's varieties.
- Reward from the 'national gene fund' for those farmers who are 'engaged in the conservation of genetic resources of land races and wild relatives of economic plants and their improvement through selection.
- Freedom of farmers to save, use, sow, resow, exchange, share or sell' their farm produce, including, seed of a variety protected under this Act in the same manner as they were entitled before the coming into force of this Act.
- Requirement for the breeder to disclose to the farmers the expected performance of the variety under given conditions; farmers can claim compensation if this expectation is not fulfilled.

The key questions relating to farmer's rights remain as whom to reward, to what extent and in what manner. It has been suggested that tribal people, rural communities and traditional farming families be rewarded. The quantum of suggested reward is around 5% of the profits. However, farmer's rights are yet to be legalized in any country, it would be a happy day when the farmers' rights are actually implemented.

**Protection of plant varieties act, 2001**

- Registration of farmers' varieties, extant varieties and new varieties of such genera and species as notified in the official gazette by the central government. A farmer's variety is a variety that has been traditionally cultivated and evolved by farmers or is a wild relative or land race in common knowledge of farmers. An extant variety is a notified variety, a farmer's variety, a variety about which there is common knowledge or any other variety that is in public domain.
- A new variety shall be registered if it meets the criteria of novelty, distinctiveness, uniformity and stability.

**Novelty:** The variety must be distinguishable for at least one essential characteristic from any other variety whose existence is a common knowledge in any country.

**Distinctiveness:** Essential characteristic should be heritable trait that contributes to the principal feature of the plant variety

**Uniformity:** The variety in ' common knowledge 'means any variety for which an application for grant of PBR or for entering the variety in the official register of varieties has been filed in any convention country should be uniform.

**Stability:** It should give stable performance over wide geographical region.

• Any variety that involve any technology like transgenic & terminator technology, which is injuries to the life or health of human beings, animal or plants shall not be registered.

• A variety that has been 'essentially-derived from an 'initial variety' can be registered as a new variety. The breeder of such a variety must obtain authorization from the breeder of the initial variety.

• The duration of protection of the varieties will be 15 year for the extant varieties, 18 year for varieties of trees and vines and 15 year for varieties of other crops.

• Registration of a variety confers on the breeder of that variety or his successor or licenses an exclusive right to produce, sell, market, distribute import or export the variety. Apparently, the protection is not limited to seed or propagules but extends to all material of the protected variety, this feature of PPVFR Act (2001) is similar to that of UPOV Act (1991).

## Conclusion

It is generally considered fair if a person that invests time and resources in developing a new invention can acquire certain rights over the invention that enable the person to recoup the investments made. In addition this is often regarded a precondition for investment and thus, innovation in any industry. IPRs have therefore gained in importance in plant breeding and plant patents are playing an increasing role. Whereas IPRs are an instrument with which plant breeders can protect the use of their varieties and biotechnological inventions.

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# CRISPR in Fruit Cultivation: A New Frontier for Quality Production

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## Introduction

CRISPR is a gene-editing technology that allows scientists to alter an organism's DNA at specific sites. Unlike older genetic modification techniques, CRISPR works by using a protein called Cas9 that can be programmed to target and cut DNA at precise points, making it possible to "edit" the genetic material of plants. This tool can remove, replace or insert new genetic sequences, giving scientists' unparalleled control over a plant's traits. For fruit crops, this means that CRISPR can help develop new varieties with improved characteristics in just a few years rather than decades. The technology allows scientists to introduce disease resistance, improved flavour, enhanced nutritional content and increased tolerance to environmental stress, such as drought and heat.

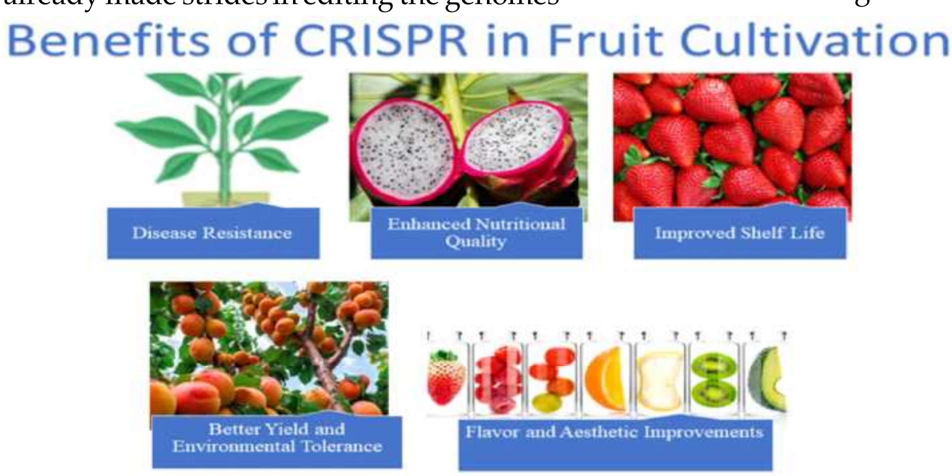
### Benefits of CRISPR in Fruit Cultivation

#### i. Disease Resistance

One of the most promising applications of CRISPR in fruit science is improving disease resistance. Many fruit crops, including bananas, apples and grapes are highly susceptible to bacterial, fungal and viral pathogens. By using CRISPR, scientists have already made strides in editing the genomes of these fruits to make them more resistant to devastating diseases. For example, researchers are working on bananas resistant to Fusarium wilt, a disease that has wiped out large plantations worldwide.

#### ii. Enhanced Nutritional Quality

Nutritional improvement is another area where CRISPR shows excellent potential. Scientists are using CRISPR to increase fruit's essential vitamins, minerals and antioxidants. Biofortified fruits such as vitamin Aenriched bananas and higher antioxidant tomatoes are developing, offer-



ing a way to combat malnutrit-ion and improve global health.

**iii. Improved Shelf Life**

Post-harvest loss due to spoilage is a significant issue for fruit producers and distributors. CRISPR can delay fruit ripening and increase shelf life, reducing waste and allowing fruits to be transported over longer distances without spoiling. The Arctic apple, for example, has been modified to prevent browning, which makes it more attractive to consumers and reduces wastage in supermarkets.

**iv. Better Yield and Environmental Tolerance**

Climate change poses a significant threat to fruit production, with extreme weather conditions such as heat, drought and frost affecting yields. CRISPR can help produce fruit varieties that are more resilient to these environmental stresses, ensuring food security in a changing climate. For example, researchers are working on heat-tolerant tomato varieties that can withstand higher temperatures, helping farmers maintain high yields even in adverse conditions.

**v. Flavor and Aesthetic Improvements**

CRISPR is also used to enhance fruit's taste, texture and appearance. Genetically edited strawberries and peaches are superior in sweetness and flavor and maintain high nutritional content. These improvements increase consumer satisfaction and boost the marketability of these fruits.

**Table 1: Applications of CRISPR technology in improving the yield, quality and sustainability of various fruit crops**

| Fruit | Targeted Trait | CRISPR Application | Result/Benefit |
|---|---|---|---|
| Banana | Disease resistance | Edited genes to resist Fusarium wilt | Increased resistance to Panama wilt disease, improving crop survival |
| Apple | Shelf-life improvement | Edited genes to prevent enzymatic browning | Arctic apples with longer shelf life and no browning, reducing food waste |
| Strawberry | Flavor enhancement | Edited genes to boost sugar content | Sweeter strawberries with improved taste and marketability |
| Grape | Disease resistance | Edited genes to enhance resistance to powdery mildew | Reduction in the need for chemical fungicides, improving sustainability |
| Citrus | Disease resistance | Edited genes to resist citrus greening disease | Better survival rates of citrus crops threatened by bacterial infections |
| Peach | Fruit texture improvement | Edited genes to regulate ripening process | Firmer peaches with impro-ved texture and transportab-ility |
| Papaya | Virus resistance | Edited genes to combat papaya ringspot virus (PRSV) | Virus-resistant papaya with improved yield and reduced crop loss |
| Blueberry | Cold tolerance | Edited genes to enhance frost resistance | Increased survival and yield in colder climates |

## CRISPR vs. Traditional Breeding: A Major Leap Forward

Traditional breeding techniques have long been the backbone of crop improvement. However, they rely on crossing plants with desirable traits and then selecting offspring that exhibit these characteristics, which can take many years and often involves trial and error. Moreover, traditional methods are limited by the genetic diversity in a species; breeders cannot introduce traits that don't naturally exist in a plant's gene pool.

CRISPR overcomes these limitations. It allows scientists to introduce new traits rapidly and precisely, even traits that aren't naturally present in the fruit species. For example, while traditional breeding could never introduce disease-resistance genes from one plant species into another, CRISPR can transfer genes between species to make a crop more resilient. This accelerates the breeding process and expands the range of possibilities for improving fruit crops.

## Ethical Considerations and Public Perception

Despite its potential, CRISPR has sparked ethical debates and public concern, particularly regarding its use in food crops. Some fear gene editing, like earlier genetic modification (GM), could lead to unforeseen environmental consequences or health risks. Others are concerned about corporate control over CRISPR-modified seeds, which could exacerbate inequalities in global agriculture.

However, many scientists argue that CRISPR fundamentally differs from traditional GM techniques because it does not necessarily involve inserting foreign genes into an organism. Instead, it can make highly targeted changes within a plant's genome, mimicking natural mutations that could occur over time. This has led some regulators to adopt a more favourable stance toward CRISPR-edited crops than older genetically modified organisms (GMOs).

## The Future of CRISPR in Fruit Science

The future of CRISPR in fruit science is bright. Researchers continue exploring new applications for the technology, including the potential to edit complex traits controlled by multiple genes, such as fruit size and yield. As the technology becomes more refined, it could pave the way for an agricultural revolution that helps meet the growing demand for nutritious, sustainable and resilient fruit crops.

In the coming years, we will likely see more CRISPR-edited fruits hitting the market, offering consumers better-tasting, healthier and more sustainable options. While challenges remain, such as ensuring equitable access to this technology and addressing public concerns, the potential of CRISPR to transform fruit cultivation is undeniable.

## Conclusion

CRISPR technology has unlocked unprecedented opportunities in fruit science, enabling swift and accurate genetic advancements that were once thought impossible. From boosting disease resistance and improving nutritional content to enhancing flavor and shelf life, this technology can revolutionize how we grow and consume fruits. As scientists delve deeper into its applications, CRISPR may become crucial in tackling global issues such as food security, climate change and malnutrition, paving the way for a more sustainable and promising future in fruit cultivation.

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# Role of Artificial Intelligence in the Advancement of Plant Pathology

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## Introduction

Plant pathology, the scientific study of plant diseases, has seen significant advancements over the years, particularly with the integration of cutting-edge technologies. Among these, Artificial Intelligence (AI) has emerged as a transformative tool, revolutionizing the way plant diseases are detected, diagnosed and managed. By leveraging AI, researchers and practitioners in plant pathology can address challenges with greater precision, speed and efficiency, ultimately contributing to sustainable agricultural practices.

### Early Disease Detection and Diagnosis

One of the most critical aspects of plant disease management is early detection. AI-powered tools, such as machine learning algorithms and image recognition systems are capable of analyzing vast amounts of data to identify disease symptoms at an early stage. For example, AI-based smartphone applications, such as Plantix and Pestoz, allow farmers to capture images of diseased plants. These applications analyze the images and provide instant diagnoses, suggesting potential treatments and preventive measures.

For instance, leaf spot diseases in crops like tomatoes and bananas can be identified through AI-driven image analysis. By using convolutional neural networks (CNNs), these systems can differentiate between healthy and diseased leaves with remarkable accuracy, minimizing the risk of crop loss. Similarly, AI has been instrumental in diagnosing diseases like bacterial wilt in tomatoes, citrus greening and powdery mildew in grapes by processing thousands of disease-specific image datasets.

### Predictive Modeling for Disease Management

AI is also instrumental in predicting disease outbreaks by analyzing environmental data such as temperature, humidity and soil conditions. Machine learning models can process historical and real-time data to forecast the likelihood of disease occurrence, enabling farmers to take proactive measures. Examples include:

- **Late Blight of Potato (*Phytophthora infestans*):** AI models can predict the risk of late blight outbreaks based on weather patterns and provide timely alerts to farmers. Historical weather data, combined with satellite imagery and soil moisture data, enhances the accuracy of these predictions.

- **Wheat Rust (*Puccinia* spp.):** Predictive models can track the spread of wheat rust based on climatic data, helping stakeholders deploy fungicides and resistant crop varieties strategically. Data collected from global networks of rust surveillance systems further refine these predictions.
- **Rice Blast (*Magnaporthe oryzae*):** AI-powered models can predict outbreaks of rice blast by analyzing regional weather patterns, crop density and field conditions.

**Enhancing Pathogen Detection through Genomics**

The integration of AI in genomics has revolutionized the identification and characterization of plant pathogens. AI algorithms can analyze large-scale genomic data to identify specific genetic markers associated with pathogenicity, virulence and resistance. This is particularly beneficial for managing soil-borne pathogens like *Rhizoctonia bataticola*, the causal agent of dry root rot in chickpeas. By identifying genetic variations in pathogen populations, researchers can develop targeted disease management strategies, including resistant crop varieties and bio-control agents.

AI also aids in analyzing metagenomic datasets to identify pathogen communities in soil and plant environments. For example, bioinformatics tools powered by AI can sift through terabytes of sequencing data to pinpoint the presence of multiple pathogens in a single sample, facilitating comprehensive disease management plans. This has been applied successfully in identifying pathogens such as *Fusarium oxysporum* (responsible for Panama disease in bananas) and *Xanthomonas oryzae* (causing bacterial leaf blight in rice).

**Automated Monitoring Systems**

AI-powered drones and sensors play a crucial role in large-scale monitoring of crop health. These systems can capture high-resolution images and detect anomalies in crop growth patterns, often invisible to the human eye. For example

- **Bacterial Leaf Blight in Rice:** AI-equipped drones can identify early signs of bacterial leaf blight, allowing for localized treatment and reducing the need for blanket pesticide applications.
- **Powdery Mildew in Grapes:** Spectral imaging combined with AI models can detect early symptoms of powdery mildew in vineyards, enabling timely intervention.
- **Downy Mildew in Cucurbits:** Automated systems equipped with AI can analyze field images to identify signs of downy mildew, providing recommend-ations for fungicide application.

Drones integrated with AI can also process spectral imaging data to assess plant health indicators, such as chlorophyll content and stress levels. This data is then fed into machine learning models to predict disease progression and recommend timely interventions.

**AI in Integrated Pest and Disease Management (IPDM)**

AI contributes to the holistic approach of Integrated Pest and Disease Management by optimizing resource utilization. Decision-support systems driven by AI recommend precise pesticide application, reducing environmental impact and costs. For instance

- **Cotton Wilt (*Fusarium oxysporum*):** AI-based systems analyze soil and plant health data to suggest crop rotation and other cultural practices to mitigate disease incidence. Soil nutrient data, combined with pathogen detection, enhances the precision of these recommendations.
- **Apple Scab (*Venturia inaequalis*):** AI tools help optimize fungicide application timing and dosage, ensuring effective disease

control with minimal residue. Historical disease data and orchard-specific climatic conditions further refine these strategies.

• **Citrus Canker (*Xanthomonas axonopodis*):** AI systems can monitor citrus orchards for signs of canker, providing actionable insights to farmers for targeted management.

**Data-Driven Research and Development**

AI facilitates the analysis of extensive datasets collected from research trials, field observations and laboratory experiments. For example, phenotypic data from disease screening trials can be analyzed using AI to identify traits associated with resistance or susceptibility. Additionally, data from global disease surveillance networks, remote sensing technologies and farmer reports are integrated into AI platforms to provide a comprehensive view of disease dynamics.

Cloud-based platforms powered by AI allow researchers to share and analyze data collaboratively. For instance, platforms like PlantVillage integrate disease diagnostics, climate data and pest monitoring to support global efforts in crop protection. Data from AI-driven platforms also enable the identification of emerging diseases, such as tar spot in maize and tomato brown rugose fruit virus (ToBRFV), facilitating the development of rapid response strategies.

**Applications in Emerging Disease Scenarios**

AI has shown remarkable potential in addressing emerging plant diseases driven by climate change and global trade. For example

• **Fall Armyworm (*Spodoptera frugiperda*) in Maize:** AI tools have been deployed to identify and monitor fall armyworm infestations using image recognition and pheromone trap data.

• **Cassava Mosaic Virus in Africa:** AI applications help in diagnosing cassava mosaic virus through mobile apps that work even in remote regions with limited internet connectivity.

• **Tomato Yellow Leaf Curl Virus:** AI-based monitoring systems track the spread of this virus by analyzing data from vector populations and infected crop regions.

**Challenges and Future Prospects**

Despite its immense potential, the adoption of AI in plant pathology faces challenges such as the high cost of technology, lack of technical expertise among farmers and data accessibility issues. Moreover, ensuring data privacy and addressing biases in AI models remain critical concerns. However, with increasing investments in agricultural technology and collaborative efforts between researchers, policymakers and tech companies, these barriers are gradually being overcome.

In the future, AI is expected to play an even more significant role in combating emerging plant diseases driven by climate change. Innovations such as AI-powered robotic systems for autonomous disease detection and treatment, coupled with advancements in precision agriculture, promise to revolutionize plant pathology further. The integration of block-chain technology with AI can also ensure transparent data sharing, fostering global collaboration in plant disease management.

**Conclusion**

The integration of Artificial Intelligence in plant pathology marks a new era of disease management, where precision, efficiency and sustainability converge. By enabling early detection, predictive modeling and optimized management practices, AI empowers farmers and researchers to protect crops and ensure food security. With continued advancements, AI will remain a cornerstone in addressing the challenges posed by plant diseases, paving the way for resilient and sustainable agricultural systems globally.

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# Modern Technology and Sustainability in Floriculture

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## Introduction

The floriculture industry, one of the largest sectors in horticulture, has seen significant advancements in recent years. With the increasing demand for flowers and ornamental plants, there's also growing pressure on the industry to adopt sustainable practices. Modern technology has enabled this transition, making floriculture more efficient, eco-friendly and adaptable to changing market demands. The Netherlands is a dominant central market for global cut flower trade. Sustainability of floriculture is aiming to reduce environmental degradation, maintaining productivity, promoting economic viability, conserving resources and energy and maintaining stable communities and quality of life. The sustainable practices include INM (Integrated Nutrient Management), IPM (Integrated Pest Management), crop rotation, efficient utilisation of water and use of energy efficient lightening systems LED's (Light Emitting Diodes).

**Modern horticulture**

Modern horticulture emphasises sustainability through regenerative practices that reduce resource use, combat climate change and utilise smart greenhouse technology to sustainably produce crops all year round. Technological innovations support climate-smart agriculture. Technologies such as sensors, climate control systems, greenhouse irrigation systems and energy-efficient heating and lighting can all be critical to advancing healthy and sustainable food production and crop production. It also focuses on sustainability by creating closed-loop systems designed to save resources, cut down on waste and reduce the carbon footprint. The increasing concerns over climate change and resource scarcity, sustainable practices have become paramount in the horticulture industry. Today's high-tech greenhouses are designed to deliver ideal growing conditions while making optimal use of the available resources and minimising the impact on the environment.

**1. Precision Agriculture in Floriculture**

Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high technology sensor and analysis tools. PA is a new concept adopted throughout the world to increase production, reduce labour time and ensure the effective management of fertilizers and irrigation processes. In floriculture, precision technology allows growers to optimize resource use, which reduces waste and maximizes plant health.

- **Soil and Moisture Sensors:** Soil sensors monitor moisture levels, ensuring plants get the right amount of water and nutrients. This not only improves growth but also conserves water.

• **Drones and Imaging:** Drones equipped with imaging technology can identify plant health issues, pests and diseases from above, allowing for early intervention.

• **Data Analytics:** By analysing data collected from sensors and drones, floriculturists can make better decisions about when to water, fertilize, or prune.

**2. Automation in Greenhouse Management**

Automation plays a crucial role in making greenhouse operations efficient and eco-friendly. Greenhouses can now use automated systems to control lighting, temperature, humidity and even irrigation based on real-time data, reducing human error and energy waste.

• **LED Lighting:** Using energy-efficient LED grow lights helps plants photosynthesize efficiently, reducing energy consumption and allowing for year-round production.

• **Climate Control Systems:** Smart thermostats and climate control systems adjust conditions to optimal levels for plant growth, improving yields and reducing the carbon footprint.

• **Automated Irrigation:** Automated irrigation systems provide water based on plant needs, reducing waste and preventing overwatering.

**3. Sustainable Practices in Floriculture**

Sustainability is at the core of modern floriculture practices. Consumers today are more environme-ntally conscious, pushing the industry towards eco-friendly practices.

• **Organic and Biodegradable Inputs:** Many floriculturists now prefer organic fertilizers and pesticides. Biodegradable pots and packaging reduce plastic waste.

• **Recycling and Composting:** Recycling water and composting plant waste are becoming standard practices in floriculture. These steps help reduce resource use and waste production.

• **Green Certifications:** Many companies are pursuing certifications like Fair Trade or Rainforest Alliance, which indicate adherence to sustainable and ethical practices.

**Fig: Vertical gardening**

**4. Vertical and Urban Floriculture**

Vertical farming, common in agriculture, is now making waves in floriculture. It allows for growing flowers and plants in stacked layers, making better use of limited space and reducing the need for large plots of land, similarly the vertical gardening is a special kind of urban gardening suitable to small spaces, particularly for decorating the walls and roofs in various styles. This is an alternative method for gardening by expanding the scope of growing plants in a vertical space. Intensive urbanization has left hardly any horizontal space for outdoor gardens. Green walls are not only spectacularly beauti-ful, but also helpful in enlivening the ambiance. Green walls can absorb heated gas in the air, lower both indoor and outdoor temperature, providing a healthier indoor air quality as well as a more beautiful space.

**Fig: Urban greenhouses**

• **Urban Greenhouses:** An urban greenhouse is an agricultural facility that produces plants in urban and semi-urban settings. They are typically less than two acres in size and are enclosed in permanently established 'greenhouses,' eliminat-ing the need for traditional field farming. Using hydroponic systems, controlled temperature, water, nutrients and light management, urban greenhouses are highly efficient in producing top-quality crops urban greenhouses allow flowers to be grown closer to city markets, reducing transportation emissions.

**Benefits of Urban Greenhouses**

• Increased Access to Fresh Produce. Urban greenhouses can provide people with access to fresh, locally-grown produce

• Improved Air Quality. Urban greenhouses can filter out pollutants from the air and reduce air pollution

• Job Creation

• Increased Biodiversity

• Improved Mental Health

• **Hydroponics and Aeroponics:** Hydroponics is a method of growing plants in nutrient-enriched water and without soil. Aeroponics is a method of growing plants without soil, where the roots are exposed to the air. The roots of the plants are exposed to nutrient-rich water. The roots of the plants are exposed to nutrient-rich mist.These soil-less growing methods use

**Fig: Hydroponic Farming System**

**Fig: Aeroponic Farming System**

less water and space, making them sustainable alternatives for urban environments.

• **Climate Adaptability:** Vertical farms can adjust to different climate conditions, making floriculture possible in diverse environments and climates.

**5. Blockchain and Transparency in Supply Chains**

Blockchain technology can help create transparency in the supply chain, from seed to sale. By tracking every step in the production and delivery process, consumers can ensure that flowers are sustainably grown and ethically sourced.

• **Product Traceability:** Blockchain provides a secure way to track the journey of flowers from farms to consumers, ensuring compliance with sustainable practices.

• **Consumer Confidence:** Knowing the origins and practices behind flower production increases consumer confidence and satisfaction.

• **Reducing Waste:** By better managing inventory and demand data, blockchain can reduce waste along the supply chain, improving overall sustainability.

## Future strategies

Modern technology has the potential to revolutionize the floriculture industry, fostering sustainability and enhancing productivity in the face of rising environmental challenges. Here are some key strategies that blend technology with sustainability for a more resilient and future-ready floriculture sector

**1. Precision Agriculture and Automation**

• **Sensors and IoT:** By using Internet of Things (IoT) sensors to monitor soil moisture, tempera-ture and humidity, growers can optimize water and nutrient usage. These data points enable precision irrigation, fertilization and pest control, reducing excess input and environmental waste.

• **Drones and Robotics:** Drones can survey large fields for disease or nutrient deficiency, while robotic systems can automate planting, pruning and harvesting. This reduces labor costs and improves accuracy in operations.

• **Data Analytics and Machine Learning:** These tools analyze data trends in real-time, predicting ideal planting and harvesting times, disease outbreaks and market demands. This helps growers minimize resource use, improve crop quality and respond proactively to challenges.

**2. Controlled Environment Agriculture (CEA)**

• **Greenhouses and Vertical Farms:** Advanced greenhouses and vertical farming setups provide controlled environments where plants grow in optimal conditions. LED lighting mimics natural sunlight, enabling year-round production and maximizing land use efficiency, especially in urban or high-demand areas.

• **Hydroponics, Aeroponics and Aquaponics:** These soilless growing methods use significantly less water and require fewer pesticides. Such systems are highly sustainable for floriculture, reducing soil depletion and water consumption while often producing flowers with vibrant colours and longer shelf life.

**3. Sustainable Resource Management**

• **Recycling Water and Nutrients:** Advanced water management systems, like closed-loop hydroponic systems, allow for recycling of water and nutrients, minimizing waste and runoff. This is especially valuable in regions with water scarcity.

• **Biodegradable and Recyclable Materials:** Shifting from plastic packaging and pots to biodegradable or recyclable alternatives reduces waste and the industry's overall carbon footprint. Such materials can be marketed as eco-friendly, appealing to environmentally conscious consumers.

**4. Genetic and Biotechnological Advances**

• **Breeding for Resilience:** Genetic engineering and selective breeding allow for the development of flower varieties that are more resistant to pests, diseases and adverse weather conditions. These plants require fewer pesticides and other inputs.

• **Enhanced Aesthetic and Functional Traits:** Biotechnology enables the development of flowers with improved colors, fragrance and shelf life. This can reduce the need for chemical preservatives during transport, especially for flowers destined for export.

**5. Renewable Energy Integration**

• **Solar and Wind Energy in Greenhouses:** Incorporating solar panels or small wind turbines can help greenhouses and other controlled environments operate sustainably. The energy generated powers lights, heating systems and other necessary equipment, reducing dependency on fossil fuels.

• **Geothermal Heating:** In areas with suitable resources, geothermal heating can maintain greenhouse temperatures in colder climates, creating year-round production with a reduced carbon footprint.

**6. E-commerce and Supply Chain Optimization**

• **Blockchain and Traceability:** Blockchain technology enables growers to trace flowers from cultivation to the end consumer. This transparency improves accountability in sustainable practices and allows consumers to verify ethical sourcing.

• **Optimized Transportation and Cold Chain Technology:** Sustainable logistics solutions, including efficient transportation routes and improved cold storage, reduce carbon emissions and minimize product spoilage, contributing to lower waste.

**7. Consumer Education and Market Alignment**

• **Eco-labelling and Certifications:** Certifications like Fair Trade and organic labels appeal to consumers prioritizing sustainability. Marketing these aspects allows floriculture businesses to capture the growing eco-conscious consumer base.

• **Sustainable Floriculture Programs:** Partnerships with environmental organizations or programs to offset carbon footprints can strengthen brand identity and educate consumers on sustainable floriculture practices.

**8. Waste Reduction and Composting Initiatives**

• **Organic Waste Composting:** Flower waste and trimmings can be composted on-site or through partnerships with local composting facilities, turning waste into valuable organic fertilizer.

• **Upcycling Plant Waste:** Some by-products, like petals, stems and leaves, can be upcycled into natural dyes or fragrance oils, creating alternative revenue streams and reducing waste.

**9. Regenerative Agriculture Practices**

• **Soil Health and Regenerative Approaches:** Practices like crop rotation, reduced tillage and using cover crops improve soil health and biodiversity.

These strategies not only make floriculture more sustainable but also support its economic viability by reducing costs, increasing product quality and opening up new markets focused on eco-friendly and ethically sourced flowers. Through innovation and a commitment to susta-inable practices, the floriculture industry can thrive while reducing its environmental impact.

## Challenges

Horticulture faces significant challenges from climate change, as abiotic stressors like extreme temperatures, precipitation events, floods, droughts, salinity, heavy metal toxicity, UV damage and air pollution increasingly impact outdoor crop produc-tion. In order to surmount these challenges, horticulture is adopting sustainable practices, developing resilient crop varieties and enhancing indoor growing practices. Protective structures such as greenhouses can play an important role in mitigating the effect of extreme weather conditions caused by climate change. Thanks to Controlled Environment Agriculture, the horticulture industry can continue to thrive, even in the face of climate challenges.

## Conclusion

Modern technology is revolutionizing floriculture, making it more efficient, sustainable and adaptable to the changing demands of both the environment and consumers. Through precision agriculture, automation, sustainable practices, urban farming and transparent supply chains, the industry is moving toward a greener future. As consumers prioritize eco-friendly products, floriculture will continue evolving, balancing beauty with responsibility. Overall, the future of floriculture is defined by innovation, sustainability and consumer focus. Embracing the newest trends and technology allows stakeholders to position themselves for success in a continuously changing market scenario while contributing to the lower industry's long-term health and viability. As the floriculture industry evolves, researchers, practitioners, politicians, and consumers must work together and innovate for a more sustainable, resilient and vibrant loral future.

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# Application of plant biotechnology in improvement of vegetable crops

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## Introduction

Biotechnology has recently created unique prospects in the field of science not only for the manipulation of biological systems for the use of human beings, several studies has been undertaken for the betterment of human beings, but subsequently it has become the fastest and quickly growing technology in the world. This technology is capable of providing skilled and affordable methods to make an assortment of new, valuable agricultural products and implements. It is possible to boost food output, reduce the use of chemicals in agriculture, reduce the costs of raw materials and minimize the environmental impacts that are connected with traditional approaches to product development through the employment of living organisms (US National Science Foundation). In addition, now biotechnology can make foods healthier and more nutritious, as it is used to improve the quality of seed grains, increase protein levels and resistance to pathogens, insect-pests as well as tolerance to abiotic stresses like droughts, floods and extreme temperatures, *i.e.* tomato has become a popular plant system because of the advanced state of its classical and molecular genetics characterization. Biotechnology is a science which depends on advances in Biology, Chemistry, Geneti cs and Genetic Engineering for its successful application in the field of agriculture. Combination of Molecular markers, genome mapping, Recombinant DNA technologies, cell and tissue culture for improvement of vegetables that forms the basis of genetic engineering of microbes, plants and animals. For the improvement of vegetable crops, tissue culture is a potential source of inducing genetic variation such as gametoclonal, somaclonal and protoclonal observed among plants.

### *In vitro* culture

The tomato belongs in the nightshade family, which includes key commercial plants such as potatoes, eggplants, tobacco, petunias and peppers (Bai and Lindhout, 2007). For quite some time, scientists could not decide on whether the tomato was a fruit or a vegetable. Genetic data (genome mapping) and morphological information were utilized to verify the Solanaceae classifications, with the *Lycopersicon* genus (*Lycopersicon* section) being used as the proof (Foolad, 2007). Because of the length of time required for breeding, traditional approaches of improvement are difficult and time-consuming. On top of that, good breeding criteria are tough to pick. It is thus a must for using cell and tissue culture for genetic improvement to use simple and effective regenerative methods (genetically transformed plants for commercial applicat-ions). High-value commercial cultivar cloning, virus-free plants and genetic alteration have all been used successfully using tomato in vitro cultivation (Li *et al.*, 2011; Yarra *et al.*, 2012; Namitha and Negi, 2013). Genetically modified tomato (FlavrSavr) was the first commercially manufactured food that received human consumption clearance. In 1994, the FDA approved the Flavr Savr tomato. The tomatoes tasted unremarkable and were unusually delicate, making shipping challenging. The first GM plant to be licensed for marketing in China was the GM tomato Huzahong No.1 (from Huzahong Agricultural University), which has increased shelf life properties. Other tomato varieties that have been approved in certain countries (the United States, Japan, Mexico and Canada) are as under (Table 1).

**Table 1. Transgenic tomato varieties approved for commercialization. Based on Yang *et al.*, (2005) and Fukkuda-Parr, (2012)**

| Company | Event | Trait | Year | Approved for | Country |
|---|---|---|---|---|---|
| Calgene | FlavrSavr CGN-89564 | Delayed softening (developed by additional PG gene expressed) | 1994 | All uses in USA; Japan and Mexico for feed and for | USA |
| Calgene | FlavrSavr N 73 1436-11 | Delayed ripening (developed by additional PG gene expressed) | 1996 | All uses in USA | USA |
| Monsanto | 8338 | Delayed ripening (developed by introduction of 1-aminocyclopropane-1-carboxylic acid deaminase (accd) gene) | 1995 | All uses in USA | USA |
| Beijing University | PK-TM8805R (8805R) | Delayed ripening | 1999 | Food, feed, cultivation in China | China |

Studies have found that high quantities of vitamins C and E and ßcarotene in vegetables, such as tomatoes, may help protect against illness risk, including malignancies and heart disease (Singh *et al.*, 1998). It involves a multi-disciplinary approach to science. Biotechnology arrived on the scene in the late 1970 and early 1980 when the several major advances in science suddenly demonstrated enormous potential for its application. In potato, it is possible to develop virus free plants by meristem tip culture. As under field conditions screening of germplasm is time consuming and expensive, barriers in sexual hybridization and therefore many inter specific and inter generic hybridizations are not successful, but it is economical and convenient at the cellular level. Such hybridizations have now been made successful in a few cases by protoplasts fusion. Similarly, maintenance of germplasm through traditional methods is expensive and by application of tissue culture, germplasm can be maintained and stored economically. Furthermore, it offers a scope to generate genetic variability through tissue culture techniques (Murashige, 1974 and Sinks and Reynolds, 1986).

**Somaclonal variation**

It has been widely exploited for the improvement of asexually propagated vegetables as potato, tomato, onion, lettuce, *etc.* In potato, early blight resistant clones could only be identified by inoculating leaves of regenerated plants with toxin derived from *Alternaria solani.* In sexually propagated crops, chromosomal rearrangements sometimes cause infertility. Somaclonal variation is neither organ nor ex-plant specific in occurance, e.g., in potato Somaclonal variation has been observed in plants regenerated from leaf discs, rachis or petiole ex-plants. In tomato, Chopra and Narasimhulu (1990) reported that somaclonal variation resulted in the recovery of about 13 different nuclear mutations among the progeny of 230 regenerates. Since plant regeneration from somatic explants is relatively early compared to either gametic cells or protoplasts, somaclonal variation can play an important role in breeding of superior vegetable variety/hybrids.

**Protoclonal variation**

As compared to callus culture the range of variation among protoclones is significantly higher. Shepard *et. al*., (1980) screened variability in over 1000 protoclones of potato variety Russett Burbank for the traits growth habit, maturation period, tuber uniformity, skin colour, etc. Some of the protoclones were resistant to symptoms caused by *Alternaria solani* toxin. Lines resistant to late blight were also recovered. Evaluation of 65 selected protoclones for 35 characters indicated significant variation for 22 characters.

**Table 2. Some useful plant variations obtained through somaclonal variation in vegetables (Kalloo, 1988)**

| Crops | Improvement |
|---|---|
| Carrots | Improved snacking characteristics (sweetness, crunchiness, crispness). |
| Lettuce | Leaf shape and leaf colour improved snacking characteristics. |
| Celery | Improved snacking characteristics. |
| Potato | Resistance too early and late blight, tuber shape, growth habit and tuber colour. |
| Sweet potato | Variety 'Scarlet' developed, which is resistant to *Fusarium oxysporum f. Batatis* and give higher tuber yields. |
| Tomato | Increased solids content, jointless pedicel and male sterility |
| Onion | Bulb shape, size and plant height. |

Resynthesis of *Brassica napusis* accomplished by fusing protoplasts of B. oleracea and B. campestris (Pelletier *et al*., 1983). Additionally, a similar result can be obtained by adding cytoplasmic male sterility genes to the vegetable onion and carrots to make hybrid seeds affordably. Helgeson *et al*., (1986) developed hexaploid hybrids resulting from protoplast fusion of *Solanum brevidem x S. tuberosum*, which showed resistance to leaf roll virus and race 'O' of late blight. Gleddlie *et al*., (1986) could fuse protoplasts of *Solanun melongena* and *S. sismbrifollum* (resistant to phomopsis blight). They observed that this resulted in aneuploids and hybrid was sterile. Hybrid plants are formed by hybrids between members of the same family that are genetically incompatible. These hybrids have the same number of chromosomes as their

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# Sorghum Breeding

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## Introduction

Sorghum (*Sorghum bicolor* L. Moench) has historically been a major staple food source globally, and is currently ranked the fifth most important cereal. Recently, it has become a multipurpose crop produced not only for food but for feed, fuel and forage, and being bred for use as a cover crop in pastures, through varieties with compacted internodes. Sorghum is serving as a vital model for tropical grass species for functional genetics and genomic studies, made possible by the availability of genomes of three sorghum lines and numerous genetic stocks and populations. It is therefore a crop of immense importance in tackling current global food security challenges.

Sorghum bicolar (2n-2x=20) comes fifth after wheat, maize, rice and barley in both area and production. It is one of the most important food crop in the semi and tropics of India, Africa. Australia, Argentina, Mexico. In India it is cultivated on large scale in Maharashtra, Gujarat, Tamilnadu, Karnataka, Rajasthan and Madhya Pradesh.

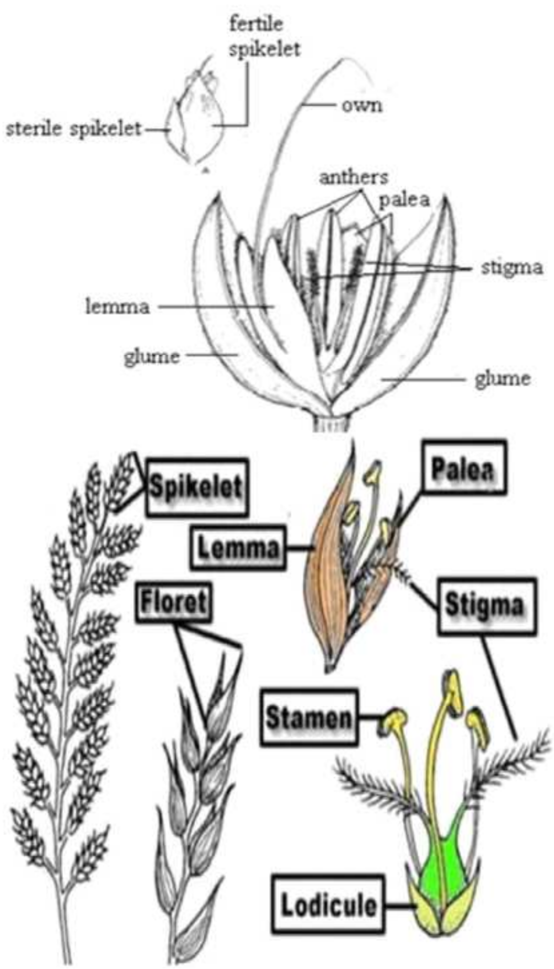
**Origin:** Sorghum is originated in Ethiopia and South Asia. The progenitor of S. *bicolar* is *sorghum arundinaceum* (2n=20). Based on inflorescence and spiklet morphology there are five major races i.e., Bicolor, Guinea, Caudatum, Kafir and Durra.

### Botany

Sorghum is annual/ perennial grass, the roots are adventitious and fibrous, stem is erect and made up of nodes and internodes, the pith may be sweet, juicy or dry. The leaves are 7 and 8 arranged alternating to opposite side with parallel venation. Presence of waxy layer limits the water loss. The panicle varies loose to compact; in some varieties panicle remains surrounded by sheath and sometimes peduncle recurred, giving pendent head referred as "goose neck". Panicle consists of spiklets in pairs; the sessile is hermaphrodite and fertile while other pedicillate are sterile. The sessile spiklet consists of inner and outer glumes enclosing two flowers, upper one is perfect and lower one is reduced. The perfect flower has thin narrow hairy lemma and small pelia enclosing three stamen, two lodicules and bifurcated feathery (brush like) stigma. The pedicillate flower is without pelia and ovary. Grain is caryopsis, endosperm is starchy and embryo consists of plumule, coleoptiles, radical coleorhizae referred as scutelum. Sorghum is breedable with S. halpense and also with sugarcane.

### Floral biology

The flowering occurs prior to sunrise and extendes up to mid-day, the blooming starts from tip of the panicle in downward direction. The stigma is receptive before flowering and remains receptive for 6 to 8 days. Pollens are viable for few hours and fertilization is completed within 2 to 4 hours of pollination, jowar is normally self pollinated crop but stigmas exposed before dehisce lead to 6 to 30% cross pollination. The glumes open due to swelling of lodicules and anther come out of stigma. The stigma remains receptive for 8 to 16 days after blooming.




**Floral biology of Sorghum**

## Emasculation

**A) Hand emasculation:** Only the part of the penduncle is emasculated. Flowered tips and lower branches are removed by clipping. About 50 florets that would flower on next day are selected and emasculated and covered with suitable paper bag.

**B) Hot water method:** In this method the sorghum head is immersed in water at 450 to 48°C for 10 minutes, without injury to the stigma.

## Pollination

Pollination is done on next day between 9 to 10 a.m., when all flower come to bloom. Inserting and shading the head in the bag collect the pollen. Another technique is clipping the heads early in the morning and placed in the boxes to flower in protected place. The collected pollens are dusted over exposed stigma or the pollen producing head brushed over emasculated head.

## Breeding objective

- High grain and fodder yield.
- Early maturity.
- Resistance to drought, low HCN content, leafy, sweet juicy fodder.
- Resistance to disease-Blight, downy mildew, rust, smut, charcoal rot, etc.
- Resistance to insect pests- Midge, stem borer and shoot fly etc.
- Bread making quality
- Wider adaptibility

## Breeding methods

### 1. Pure line selection

In this method superior land races are selected from local uniform variety and grown as plant progenies in the next year. Uniform superior progenies harvested and bulked as improved strain for further evaluation. In varietal evaluation, if improved strain shows superiority over the existing variety, it is released for commercial cultivation on large scale. Eg. 1) M-35-1, 2) Sel-3, 3) Yashda, 4) Maulee (RSLG-262).

### 2. Pedigree method

This method consists of hybridization between desirable parental lines, followed by selection of superior plants, in the segregating generation, till homozygosity is achieved. i.e. F5-F6. The selected plants are bagged to prevent out crossing. Varieties developed by pedigree method are SPV-86 ( R-24 X R-16), SPV-504 (Swati) (SPV 86 X M-35-1), CSV -15 R, ( SPV-475 X SPV-462).

**3. Back cross breeding**

It is used to transfer one or few inherited traits from donor to another desirable genot-ype (recipient parent) resistance to disease like grain mold, downy mildew, rust, smut and resistance to insect pest like midge, shoot fly, stem borer could be introduced in desirable strain by back cross breeding. Similarly cytoplasmic genetic male sterility could also be introduced by this method.

**4. Hybrid breeding**

Seeds of hybrid sorghum are produced using cytoplasmic genetic male sterility typically known as A, B and R line system. Combine Kafir- 60 (m.s) was initial male sterile line is used in hybrid seed production. Male sterile line is known as a line and its maintainer is known as B line. Line A and B are isogenic except that line A is male sterile line and B is male fertile. The difference lies only in cytoplasm, where line A has sterile cytoplasm and line B has fertile cytoplasm. Any fertile line can be converted into male sterile by backcross breeding method.

**A) Maintaince of A, B and R lines**

A planting A and B line in 4:2 ratios in isolated field for maintenance male sterile line A. Seed produced on A line is male sterile. Line B is self fertile growing crop in isolation or bagging the heads of B line plants, maintains B line. Similarly line R is also self fertile, is also multiplied by planting in isolated field. In commercial seed production, i.e., bulk production of A, B and R line is referred as foundation seed production and production of A X R referred as certified seed production.

**A Line (msms) × B Line ( msms) = A line (msms)**

**Male Sterile × Male Fertile = Male Sterile**

**A Line ( msms ) × R Line ( MsMs) = (Msms) Hybrid Seed**

**Male sterile × Male Fertile = Male Fertile**

New hybrids can be developed by improving performance of 'A' and 'R' lines or both by the back cross breeding method. Every year crossing programme of restorers with promising male sterile lines is undertaken and hybrids are tested for performance. If performance of particular hybrid found superior, it is multiplied on large scale for commercial cultivation. The popular hybrids are CSH-1, CSH-5, CSH-12, CSH-15 and CSH-16.

**5. Resistance breeding**

The resistance could be incorporated in given strain when desirable donor present is available by back cross breeding. Effective identification of donor and screening technique of mode of inheritance in needed, the characters controlled by dominent gene could easily be transferred by back cross breeding than character controlled by recessive genes. The important resistance source for pest and disease are given below.

**A) Pest resistance**

**Shoofly:** IS-1034, 1054, 9136, 8314- Non preference for oviposition.

**Stem Borer:** IS-1054, 1034- Oviposition non preference

**Midge:** EC- 92792, DJ-6514, IS-18753-Non Preference of host susceptibility is dominant.

**B) Disease resistance**

**Head mold:** CSV-4, CSV-5 and SPV-35- incomplete dominant.

**Downy mildew:** CSV-4, CSV-5, SPV-105 and CSH-5 - Resistance is recessive.

**Charcoal rot:** CSV -5, SPV-104,

**Leaf disease:** 2219A, 2077A, CSH5, CSV-4, CSV-5, SPV-104, - Resistance is recessive.

**Rust:** 2219A, 296A, CS-3541, CSH-5 - Resistance is dominant.

The plant types have generally higher

degree of resistance to foliar diseases.

**Breeding for striga resistance**

Striga weed is an important root parasite on sorghum and other grasses. Strigol is stimulant produced by host is required for germination of host. The resistance reaction includes low production of stimulant and mechanical barrier to haustorial penetration in the host plant.

**Breeding for forage quality**

Sorghum is grown for grain and fodder the forage type varieties should have high tonnage, more leafiness, juiciness, sweetness, good palatability and higher digestibility. Sorghum X Sudan grass is grown widely and has less problems of hydrocynic acid content (HCN).

**Back cross method**

This method is used when variety otherwise is good, high yielding but deficient in simply inherited trait. The obvious effect of this method is production potential of improved variety is fixed at the level of recurrent variety. Recently identified donors always are used in back cross breeding programme.

**Multiline breeding**

It is extension of back cross breeding and could be called Multilateral backcrossing. It consists of spontaneous back cross programme to produce isogenic lines for resistance to disease, in back ground of some recurrent parent. Each isogenic line will be similar to recurrent parent but they will differ for resistance to various physiological forms of diseases. A mixture of these isogenic lines is called multiline variety.

**Mutation breeding**

This method is used in depleted gene pool situation. Chemical mutagenes EMS provide broad spectrum genetic changes with lesser sterility effects, as compared to x ray or particular mutation.

**Molecular marker-assisted selection**

This uses classical, backcrossing, or inbreeding and hybridization methods, with an important difference. Instead of selecting desirable plants based on the way they look or grow breeders select plants after confirming the information on the genes the plants inherited from their parents. Just like having a map to an unfamiliar city, this takes some of the guesswork out of breeding. Researchers can confirm the gene is present, not just assume it is, before they move forward with breeding the plant.

**Gene editing**

These cutting-edge genetic techniques, including CRISPR-Cas9, enable breeders to modify specific genes directly. It targets very specific plant characteristics with razor-like precision.

**International and National Programmes**

The international crop research institute of semi arid tropics (CRISAT) has released sorghum varieties ICSV-112 (SPV-475) and as CSV-13 for general cultivation in India. ICRISAT is working with collaboration of NRCS (National Research Centre on Sorghum) at Nation level at Sholapur.

**Conclusion**

Sorghum is staple food in semi arid tropics, which provides nutrition to millions of people in Africa and Asia. There are acute food crises in African continent. Therefore it is necessary to improve grain yield of sorghum through genetic enhancement through breeding methods.

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# Exploring Organic Pest Control Methods

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## Introduction

In organic systems, pest control relies on guarding against financial harm caused by pest issues. By using different rotations and providing habitat for beneficial creatures where it can also lessen the habitat for pests, prevention can also help to preserve a lively and healthy soil ecology. We can learn more about the population status of both pest and beneficial insects by routinely monitoring the crop. It's critical to be able to distinguish between pests and beneficial insects, as well as their many life stages and habitats. Physical and cultural controls are examples of preventive approaches. If these methods are unsuccessful in reducing insect numbers, the last resort is the use of legal pesticides. Pheromone traps, the release of helpful insects, the cultivation of trap crops and other approaches that have been approved can all be used for organic pest control. From a practical standpoint, organic systems rely on methods like crop rotation, green manure, compost and biological pest management instead of allowing the use of agrochemicals and outside inputs to enhance the environment and farm economics.

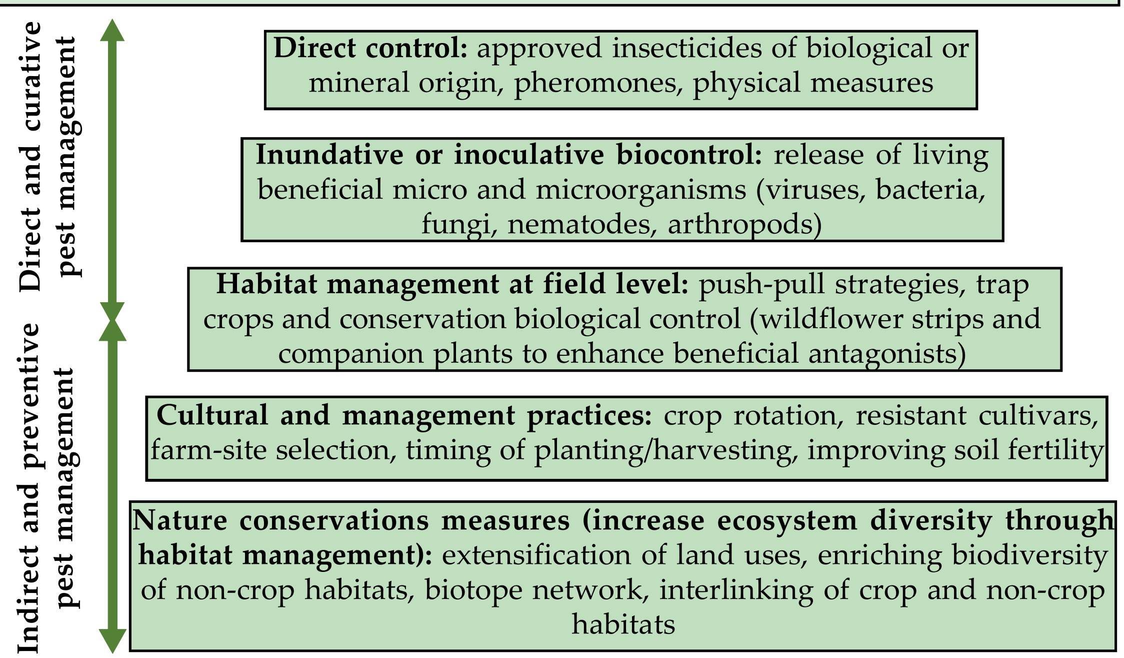


**Fig. 01 Conceptual model of pest management in organic farming**

Although synthetic petrochemical fertilizers and pesticides, plant growth regulators like hormones and antibiotic application in livestock may be used, natural fertilizers and pesticides (herbicides, insecticides and fungicides) such as pyrethrums from chrysanthemum flowers may still be used.

**Organic Pest Control Methods**

**1. Cultural Practices:** For protecting the crop from pests, some traditional cultural practices can be done which includes-

• Crop Rotation • Intercropping

The most effective strategy for keeping pests away from cultivated plants is crop rotation. This approach involves growing different crops every year. The soil's fertility is also increased by this agricultural technique. Crop rotation for pest control is effective against pests with a constrained host range and a constrained ability to disperse. A three-year rotation effectively controls maize rootworm. It is a crucial way to control the insect that infests cabbages. When two or more crops are grown simultaneously on the same field, this practice is known as intercropping. There will still be a set distance between crops of the same kind. Therefore, this method is effective at driving pests away from the intended host plant. Planting a crop in close proximity to a crop that could be attacked by an insect that has the ability to attract, repel or both on a targeted insect. Three mechanisms exist:

• Trap cropping
• Repellent Intercrops
• Push-Pull cropping

**Trap Cropping:** Trap cropping refers to the technique in which the attractant crop is positioned close to the production crop. Insects are attracted to the crop because the plant used as an intercrop is more appealing to them than the crop utilized for production.

**Repellent Intercrops:** The control of insect pests can also be accomplished by using an intercrop with a repellent effect. In comparison to a trap crop arrangement, this frequently necessitates planting the intercrop in more rows. The production crop is protected from the insect pest in this method by the repellent intercrop, which also serves to keep the insect away from its host crop. A study that demonstrated that intercropping leeks with beans (the host plant) had a repellent effect on the bean fly provides a better illustration of repellant intercrops.

**Push-pull cropping:** An intercropping method can be used in this to reduce insect pests by combining crops that repel insects and crops that attract them. In this scenario, the attractant crop serves as the "pull" while the repellent crop serves as the "push" to repel the bug.

**2. Mechanical or Physical Pest Control:** This is the most basic form of pest control, which also includes barriers, tillage, mulching, cutting and mowing. Includes weeding by hand and simply picking insects. Row covers and protective nets with different mesh sizes depending on the pests can also be used to protect crops from pests. Utilizing insect vacuums, insects can be removed off plant surfaces and gathered in a box. Insects can be removed from surfaces using water spray.

**3. Oil Sprays:** The pests are suffocated by these oil sprays. Spraying it directly on the pests increases its effectiveness. Spraying should be avoided on hot summer days and on plants that are moisture stressed. Spraying possible oils on bare plant branches to kill insect eggs. Additionally, seafood and plants can be used to produce allowed oils. Fish oils are by-products of the fish processing industry, whereas plant oils are largely made from seeds (such as soyabean, cottonseed, sesame and canola). Currently offered goods also fall into the area of blends of several essential plant oils, including rosemary, wintergreen and clove. Instead of seeds, these are typically extracted from leaves, stems or flowers and then the components are separated using distillation. Spray oils work well against arthropods with soft bodies. To combat mites, aphids, whiteflies, thrips, mealybugs and scale insects, they are most frequently utilized. Because oils lack residual activity, they do not provide control of insects moving into a treated area, hence they are also employed against overwintering eggs and scales.

**4. Sticky traps:** Most Sticky traps don't include insecticides, though some could be scented to attract particular pests. These sticky traps can help a professional find pest more easily while doing pest control inspections since they can be used to continuously monitor a space for crawling insects. For instance, cucumber beetles will be drawn to a mobile trap that is white in color. The yellow trap can be used for Whiteflies, fruit flies and all other common insects.

**5. Biological way of pest control:** The use of living natural enemies to manage pests is known as biological control. To lower pest population densities, hostile organisms are actively manipulated. Predators, parasites, parasitoids, diseases, or rival pest species are some examples of these. There are four methods/types in it:

i. Augmentive Biological Control

ii. Classical Biological Control (Introducing new natural enemies and establishing permanent population)

iii. Inundative Biological Control

iv. Manipulative Biological Control

**Augmentive Biological Control:** Releasing a huge number of biological control agents to enhance the existing minimal quantity. For Example: The lychee orchard is being severely damaged by a stink bug; a helpful wasp is naturally present but only kills 10% of the eggs. The killing of many more eggs occurs when many more of the same wasp species that were raised in an insectary are released. For the remainder of the fruiting season, wasps reproduce and lower damage to below the economic threshold.

**Classical Biological Control:** Import and release of biological control agents with the goal of establishing a long-term population in a region where they are not currently existent. Releasing biological control agents in a region where they cannot survive permanently owing to harsh environment or other restrictions is characterized as Seasonal Inoculative Biological Control, a subset of this. The employment of the parasitic wasps Pediobius foveolatus against Mexican bean beetles and Edovum puttleri against the Colorado potato beetle are two instances of seasonal inoculative discharge in the field.

**Inundative Biological Control:** Releasing a biological control agent in greater quantities than the target species in anticipation of a quick impact. It is not implied that the biological control agent that was released will grow a persistent population. Instead, the plan is to release biological agents-similar to pesticides-in sufficient quantities to reduce the pest population. The majority of insect pathogen formulations that are commercially available are frequently utilized.

The most well-known biological insecticides are those based on the bacteria Bacillus thuringiensis. A Bt spray essentially acts as an insecticide by paralyzing the insect's stomach. In many products, there are no viable bacterial spores present; only a formulation of the active protein, which is a protein, produced by the bacterium and paralyses the stomach. As a result, the disease does not continue to spread among insects. Live natural enemies that are released inundatively include beneficial nematodes. These nematodes actively assault their insect hosts as they move through the soil or on its surface. As soon as they are inside, they release symbiotic bacteria, which grow and eventually destroy the host. After consuming the bacteria and insect tissue, the nematodes reproduce by mating. New, juvenile nematodes emerge from the insect carcass to look for new victims after one to two weeks. Nematodes are extremely sensitive to desiccation, ultraviolet radiation and temperature fluctuations. They are especially effective against insects that live on, in or near the soil, as well as those that tunnel within plants or in other safe places. Due to the costs of mass rearing, storing and transporting live creatures in the requisite quantities, the inundative release of insect and mite natural enemies in the field is still quite expensive. However, research into synthetic predator meals and other areas of commercial production is continuing to reduce the price.

**Manipulative Biological Control:** Manipulation of environmental factors to increase the activity and number of natural enemies. As an illustration, water pools in a salt marsh are connected by channels. This makes it possible for naturally occurring predatory fish to enter pools and consume mosquito larvae.

**Conservation Biological Control:** Using less pesticide is important because most natural enemies are quite vulnerable to them, which significantly reduces their field effectiveness. The original concept that gave rise to integrated pest management (IPM) was to combine biological and chemical control by using the fewest pesticides necessary for economic production and applying those that were needed in a way that did not interfere with biological control agents. The use of pesticide-resistant cultivars, cultural practices that lessen pest abundance or harm, techniques for influencing insect mating or host-finding behavior and in some situations, physical methods of control can all help to reduce the need for pesticides.

**6. Biopesticides:** In biochemical pesticides, pests are controlled by naturally occurring chemicals. These include potassium bicarbonate, hydrogen dioxide, phosphoric acids, plant extracts and botanical oils as substances that treat ailments.

Biopesticides don't hurt farmers or plants. Neem is the most popular bio-pesticide used by Indian farmers. Crops can be treated with neem water to keep pests away. Environmental risk does not exist with biopesticides. These pesticides have somewhat strict application requirements and a sluggish rate of action. Bio-pesticides, however, don't harm crops because they don't leave behind any issues.

**Microbial pesticides:** Micro-organisms serve as the primary active element of microbial biopesticides, which work as biological control agents, influencing the pathogen either directly or indirectly through the substances they generate or by inducing particular plant responses. The poisonous metabolites produced by microbes are used to kill and stop the spread of pests. These are applied using a variety of methods, including extrusion, electro-spraying, fluidized beds, spray drying and emulsion.

**Example**: According to reports, the fungus *Trichoderma* sp. inhibits the growth of a variety of soil-dwelling fungi responsible for the root rot of groundnut, black gramme and green gramme. The control of worms, beetles, weevils, aphids, whiteflies and mite infestation in fruits and vegetables has been attributed to *Beauveria bassiana.*

*Bacillus thuringenisis* (Bt) is a well-known bacterial insecticide that is used for commercial purposes. Bt is used to lessen pest infestation in plants like potatoes and cabbage. It is also effective at controlling lepidopterans in various plants.

**Nano biopesticides:** These can be characterised as nanotechnology developed biological protection products with improved efficacy and lower pesticide environmental loads.

## Conclusion

Pest control in organic systems relies on shielding the pest issues from financial harm. In turn, this protection depends on preserving a robust and healthy soil ecology, supporting the biodiversity above ground through varied rotations, providing habitat for beneficial creatures and minimising the habitat of pests. If approved pesticides are used and preventive measures, such as physical and cultural controls, fail to manage pest populations. Monitoring the crop on a regular basis can give information on the state of the pest and beneficial population. Being able to distinguish between pests and beneficial's and which ones are both, as well as the many life phases of pests and beneficial's and their habitats, is crucial. Therefore, it is necessary to alter agricultural practises in the most vital and important areas, such as the reduction of non-selective pesticides to prevent adverse impacts on beneficial arthropods.

**System:** Based research that thoroughly combines the biological, chemical, physical, ecological, economic and social sciences is necessary for the preventative approach to crop protection (Lichtfouse *et. al.*, 2009). Sustainability entails maintaining economic production while considering farming's effects and ecological foundation seriously. It entails creating robust systems that can stand the test of time (Francis and Porter, 2011).

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# Plant Growth Regulator in Fruit Crop

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## Introduction

A plant growth regulator (PGR) is a natural or synthetic chemical substance that influences the growth and development of plants. These substances function by modifying physiological processes such as cell division, elongation, differentiation, flowering, fruiting, dormancy, and senescence. Auxins, gibberellins, cytokinins, ethylene and abscisic acid are the five primary types of PGRs, and each has a specific role in plant physiology. It is a typical occurrence for low-quality fruits to be produced. Therefore, it would be beneficial to apply plant growth regulators topically to increase the productivity and quality of fruit harvests.

Growth regulators are now a crucial part of agro-technical processes for the majority of cultivated plants, but particularly for fruit plants. Thus far, exogenous application of plant growth regulators has been used to prevent excessive fruit drop in fruit crops. Auxin and gibberellins are frequently used to reduce fruit drop and enhance fruit quality. Some fruits are eliminated from fruit set to final maturity by a number of factors during the ontogenic development from fruit set to fruit ripening and final customer reach.

**PGRs classified into two categories:**

**1. Natural PGRs (Phytohormones):** These are organic substances that plants naturally create, such as:

a. Auxins
b. Gibberellins
c. Cytokinins
d. Ethylene
e. Abscisic acid (ABA)

**2. Synthetic PGRs:** These are artificially synthesized chemicals that mimic or inhibit the action of natural plant hormones, such as

a. Synthetic auxins (e.g., 2,4-D)
b. Growth retardants (e.g., paclobutrazol)

**a. Auxins**

Auxins are crucial in promoting cell elongation, root formation, and regulating fruit development. One of the common auxins is indole-3-acetic acid (IAA), which helps in the elongation of cells in the stem. They are extensively used in agricultural practices, particularly in

- **Rooting Hormones:** To encourage root development in plant cuttings.
- **Weed Control:** Specific synthetic auxins act as herbicides.
- Auxins, such as NAA are used to increase fruit set in crops like cherries, apples, and mangoes.
- **Fruit drop prevention:** In crops like citrus and mango, auxins (such as 2,4-D) or cytokinins can stop early fruit drop.

**b. Gibberellins**

Gibberellins facilitate significant growth in the plant, especially in terms of seed germination and stem elongation. They are crucial for:

- **Breaking Dormancy:** Gibberellins can help seeds germinate even in unfavorable conditions.

• **Blooming Management:** Induction of Flowering: Citrus and other fruit crops use gibberellins (such as GA3) to encourage blooming.

• **Inhibition or delay of flowering:** Gibberellins can also be employed in grapes to synchronise the crop and delayed flowering.

• **Enhancing Fruit Size:** By encouraging cell elongation and division, gibberellins (such as GA3) are used to make grapes, citrus fruits, and cherries larger.

• **Cold stress tolerance:** Gibberellins can help apples and grapes withstand cold.

**c. Cytokinins**

Cytokinins are primarily responsible for promoting cell division and can delay aging in plants. They are commonly used in:

• **Micropropagation:** Assisting in the rapid multiplication of plants in controlled conditions.

• **Fruit and Flower Development:** Enhancing the longevity of cut flowers.

• **Decreased senescence and decay:** In crops like apples and cherries, cytokinins postpone the ageing of leaves and fruits.

**d. Ethylene**

Ethylene is a unique PGR as it is a gas at room temperature. It plays a pivotal role in

• **Fruit Ripening:** Most fruits produce ethylene to trigger ripening. In crops like bananas, mangoes and tomatoes, ethylene (e.g., ethrel/ethephon) speeds up the ripening process.

• **Abscission Process:** Involved in the shedding of leaves and fruits.

• **Enhancing flavour and colour:** Ethylene promotes the development of colour in tomatoes, apples and citrus fruits.

**e. Abscisic Acid**

Abscisic acid is essential in helping plants manage water stress. It plays significant roles in

• **Drought tolerance:** Abscisic acid (ABA) improves fruit crops like grapes and citrus by minimising water loss through stomata closure.

• **Seed Dormancy:** Prevents germination during unfavorable conditions.

• **Delaying ripening:** To extend the shelf life of apples and bananas, abscisic acid or inhibitors such as AVG (aminoethoxy-vinylglycine) postpone ripening.

**Synthetic PGRs**

Plant height can be controlled by growth retardants such as paclobutrazol.

**Controlling excessive vegetative growth:** To improve flowering and decrease vegetative growth, mangoes and other fruit crops are treated with growth retardants such as chlormequat and paclobutrazol.

Serve as herbicides, such as 2, 4-D for weed control. Use retardants like AVG to postpone fruit ripening in order to increase shelf life.

The functions of PGRs are quite varied and essential for plant development. Here are some critical roles they play:

• **Growth Regulation:** PGRs determine the overall height, size, and structure of plants.

• **Fruit Development:** They assist in the growth and maturation of fruits.

• **Stress Response:** PGRs help plants cope with environmental stress like drought.

• **Flower Initiation:** They promote flowering and seed production.

• **Crop Production:** Enhancing crop yields by optimizing growth conditions.

• **Post-harvest Treatments:** Controlling ripening and extending the shelf life of fruits and vegetables.

• **Pest and Disease Management:** PGRs can improve a plant's defense mechanisms against pests.

• **Ornamental Plants:** Creating more appealing flowering plants for gardens and landscapes.

**Challenges and Concerns**

Despite their numerous benefits, the use of PGRs does come with challenges. Some potential concerns include:

- **Overuse:** Excessive application can lead to plant damage and reduced efficacy.
- **Environmental Impact:** The consequences of synthetic PGRs on ecosystems are still under study.
- **Market Regulations:** There are strict guidelines governing the use of PGRs in agriculture.

**Conclusion**

In conclusion, Plant Growth Regulators are a powerful tool in modern horticulture and agriculture. By understanding their types, functions, and applications, we can utilize them effectively to promote healthy plant growth and improve agricultural productivity. As students and future farmers, appreciating the role of PGRs can lead to better farming practices and enhanced food security in our communities.

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# "Cultivating the Future: How IT is Transforming Agriculture"

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## Introduction

In 2024, agriculture is being revolutionized by cutting-edge IT techniques. Artificial Intelligence (AI) and machine learning optimize crop yields by analyzing soil, weather and pest data in real-time. IoT-enabled smart farming systems use connected sensors to monitor soil moisture, temperature and nutrient levels, automating irrigation and fertilization. Blockchain enhances supply chain transparency, ensuring food traceability and reducing waste. Precision agriculture powered by drones and satellite imagery enables targeted crop treatment. Robotics is transforming harvesting and planting processes. Additionally, digital twin technology simulates farm conditions, aiding decision-making. These innovations collectively boost productivity, sustainability and efficiency in modern agriculture.

Here's a comprehensive overview of the latest IT techniques revolutionizing agriculture in 2024. These advancements address challenges such as resource optimization, climate resilience and the need for sustainable farming.

### Artificial Intelligence (AI) in Agriculture

#### Generative AI

Generative AI, one of the most transformative tools in agriculture, leverages big data to make precise recommendations. AI-driven systems analyze weather patterns, soil conditions and crop needs to optimize planting schedules, fertilizer application and pest control.

**Applications**

- Digital crop advisors provide tailored farming practices.
- AI predicts weather trends to minimize

risks from climate variability.

• AI systems track pest outbreaks and suggest preventive actions.

**Computer Vision**

AI-powered computer vision uses cameras and sensors to monitor crops and livestock. Applications include detecting plant diseases, counting crops and monitoring livestock health.

**Digital Twins**

Digital twins are virtual models replicating physical farm systems. They simulate farming conditions to test the efficacy of techniques and inputs before implementation.

**Key Benefits**

• Reduced cost and time in field trials.

• Simulation of weather impacts and pest dynamics.

• Optimization of irrigation systems using synthetic and real data.


**Internet of Things (IoT) and Smart Sensors**

IoT-enabled sensors collect real-time data on soil moisture, temperature and crop health. These devices enable farmers to implement precision agriculture, minimizing resource wastage while maximizing yield.

**Use Cases**

• Monitoring soil health with nutrient-specific sensors.

• Automated irrigation systems adjust based on moisture data.

• Weather stations predict microclimates, helping farmers respond proactively.

**Drones and Unmanned Aerial Vehicles (UAVs)**

Drones are increasingly vital for crop monitoring, field mapping and precision spraying.

**Capabilities**

• High-resolution imaging for crop stress detection.

• Pesticide application reduces waste by up to 60%.

• 3D soil mapping improves land-use strategies.

**Autonomous Machinery**

Autonomous tractors and robotic harvesters are reshaping labor-intensive agricultural processes.

**Technological Features**

• GPS-enabled navigation for precise planting and harvesting.

• Sensor integration for real-time machine health monitoring.

• Multi-tasking capabilities, such as seed planting and weed removal.

**Advanced Data Analytics**

Big data analytics allows farmers to interpret complex datasets and gain actionable insights.

**Key Functions**

• Predictive analytics for yield forecasting.

• Decision support systems for irrigation and fertilization.

• Analysis of historical data to improve crop rotations.

**Cloud Computing**

Cloud platforms store, process and share agricultural data in real-time, fostering collaboration among stakeholders.

**Advantages**

• Centralized access to field data for researchers and farmers.

• Scalable solutions for multi-seasonal monitoring.

• Facilitates remote advisory services.

**Blockchain in Agriculture**

Blockchain enhances transparency and efficiency in agricultural supply chains.

**Applications**

• Tracing food origins for quality assurance.

• Smart contracts automate transactions between farmers and buyers.

• Real-time monitoring of produce from farm to table.

**Regenerative Agriculture Tools**

Technologies supporting regenerative agriculture are gaining momentum.

**Innovations**

• Digital platforms tailor soil health strategies.

• Tools for adaptive grazing optimize carbon sequestration.

• AI-powered systems monitor bio-diversity and ecosystem recovery.

**Sustainable Farming and Climate Resilience**

Tools like generative AI and advanced sensors focus on climate-resilient practices, such as minimizing greenhouse gas emissions and improving water efficiency.

**Features**

• AI predicts droughts and suggests mitigation strategies.

• Smart irrigation systems conserve water by responding to real-time soil data.

**Enhanced Supply Chain Solutions**

Technology addresses inefficiencies and vulnerabilities in food supply chains.

**Recent Trends**

• Shorter supply chains emphasize local sourcing.

• IoT devices monitor storage conditions to reduce spoilage.

• Consumer apps promote traceability and minimize food waste.

**Emerging Trends in Agritech**

**1. AI-Powered Market places:** Digital platforms connect farmers with buyers, offering real-time pricing and demand forecasts.

**2. Vertical Farming IT Systems:** Urban farming uses IoT and AI to control light, temperature and nutrients in vertical setups.

**3. Alternative Proteins:** IT tools streamline the production of plant-based and lab-grown proteins.

**Challenges in Adopting IT in Agriculture**

• **Connectivity Issues:** Rural areas often lack internet infrastructure.

• **High Costs:** Advanced tech can be expensive for smallholders.

• **Skill Gaps:** Farmers may require training to utilize modern tools effectively.

**Conclusion**

As IT innovations mature, agriculture is poised for a transformative era. Collaborations between tech companies, governments and farmers will be key to ensuring widespread adoption of sustainable practices. This synthesis of IT and agriculture represents not only an opportunity to enhance productivity but also a path toward addressing global challenges such as food security, climate change, and environmental degradation. These technologies are not only transfor-ming productivity but also addressing environmental challenges by reducing waste, enhancing water efficiency and lowering carbon emissions. The adoption of such tools signals a significant step toward sustainable and resilient agricultural systems.

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# Establishment of an Orchard and Its Management with Modern Technology

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## Introduction

The establishment of an orchard requires meticulous planning, site selection, soil preparation and the selection of suitable varieties for long-term productivity. Traditional practices in orchard management have been largely manual, but the advent of modern technology has introduced precision techniques that increase efficiency, reduce resource waste and enhance the quality of produce. This article will cover the essential steps in orchard establishment and explore how modern technology can revolutionize orchard management.

### Site Selection and Land Preparation

The success of an orchard begins with selecting the appropriate site, considering factors like climate, soil type, water availability and elevation. Key criteria include

- **Climate Compatibility:** Ensuring the chosen fruit species and variety are suited to the local temperature and rainfall patterns.
- **Soil Quality:** Testing for fertility, pH levels, and drainage capacity. Modern soil testing kits and mobile labs help in detailed soil analysis, allowing for more precise amendments.
- **Water Resources:** Proximity to a reliable water source and the quality of water should be assessed using modern irrigation planning tools.

Land preparation involves clearing the land, levelling, plowing and incorporating organic matter. Technologies such as GPS-guided tractors, laser land-levellers and soil moisture sensors aid in optimizing these activities.

### Orchard Layout Design

A well-planned orchard layout maximizes space efficiency and ensures easy access for management activities. Using tools like Geographic Information Systems (GIS), orchardists can design layouts that optimize row spacing, sunlight exposure and airflow, which are essential for healthy growth.

- **Row and Plant Spacing:** Based on tree canopy size, rootstock and machinery access. Precision planting machines help achieve uniform planting and spacing.
- **Windbreaks:** Natural or artificial barriers to protect orchards from strong winds can be strategically placed using GIS and other planning software.

### Selection of Suitable Varieties and Rootstocks

Selecting the right variety and rootstock is crucial for ensuring the orchard's success. Modern nurseries offer disease-resistant and high-yielding varieties suited to specific climatic conditions. With advances in biotechnology, genetic mapping of fruit varieties allows for the selection of rootstocks with specific traits such as dwarfing, tolerance to drought and resistance to soil-borne pathogens.

**Irrigation Management**

Water is a critical resource for orchard success. With modern irrigation technology, water management has become more efficient and precise.

• **Drip Irrigation Systems:** These systems deliver water directly to the root zone, minimizing water wastage. Modern drip systems are equipped with automation and remote sensing technology that adjust water delivery based on soil moisture levels.

• **Smart Irrigation Controllers:** These controllers use weather data and soil moisture sensors to automatically adjust the irrigation schedule, ensuring that trees receive optimal water for growth without over-irrigating.

**Nutrient Management**

Proper nutrition is essential for the healthy development of orchard trees. Advances in technology have facilitated more accurate and sustainable nutrient management

• **Soil Testing and Fertilizer Application:** Precision nutrient management is driven by regular soil testing, allowing the application of the exact amount of fertilizers needed. Technologies like variable rate technology (VRT) apply fertilizers at different rates across the orchard, ensuring uniform growth.

• **Fertigation Systems:** These systems integrate fertilizer application with irrigation, ensuring that nutrients reach the plant's root zone effectively. Controlled by automation, these systems prevent nutrient leaching and over-fertilization.

**Pest and Disease Management**

Pest and disease outbreaks can severely affect orchard productivity. Modern Integrated Pest Management (IPM) uses a combination of biological control, chemical treatments and advanced technologies to manage pests sustainably.

• **Remote Sensing and Drones:** Drones equipped with multispectral cameras can monitor orchards in real-time for early signs of pest infestations and diseases. These images provide data that helps detect stressed plants before symptoms are visible to the naked eye.

• **Artificial Intelligence (AI) and Machine Learning (ML):** Algorithms can now predict the risk of pest outbreaks based on weather data and orchard conditions, allowing growers to take pre-emptive actions.

**Pruning and Canopy Management**

Regular pruning is necessary for shaping the tree, improving sunlight penetration and maintaining airflow. Traditional pruning methods can be time-consuming, but modern machinery and techniques have revolutionized this process.

• **Mechanized Pruning:** Mechanical prunes significantly reduce labor and time required for canopy management, providing consistent results.

• **Light Detection and Ranging (LiDAR):** LiDAR sensors help map the tree canopy, enabling more accurate pruning and thinning decisions.

• **Harvesting Technologies:** Harvesting fruit at the right time and minimizing damage are crucial for preserving quality. The use of modern mechanized harvesters and sensor-based tools can increase efficiency while reducing labor costs.

• **Automated Harvesters:** These machines can harvest fruits like apples, pears and citrus with minimal damage, increasing efficiency compared to manual harvesting.

• **Sensor-based Maturity Detection:** Using hyperspectral imaging and colour sensors, fruit maturity can be assessed on the tree, ensuring that only ripe fruits are harvested.

**Post-Harvest Technology**

Proper handling and storage of fruits after harvest are essential to prevent spoilage and maintain quality. Advanced post-harvest technologies include

- **Cold Chain Management:** Refrigerated storage and transportation systems maintain optimal temperature conditions to extend fruit shelf life.
- **Ethylene Control:** Advanced packaging materials and storage rooms with ethylene control systems delay ripening and reduce spoilage during transit.

## Conclusion

The establishment and management of an orchard have evolved significantly with the incorporation of modern technology. From site selection to harvesting and post-harvest handling, the use of precision tools and automation has not only improved productivity but also reduced labor costs and environmental impacts. The future of orchard management will continue to be shaped by emerging technologies such as AI, machine learning and robotics, leading to even greater efficiencies and sustainability in fruit production.

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# Horticulture for Hope

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## Introduction

Horticulture is the art and science of growing plants, but its impact extends far beyond the fields and greenhouses. It is a practice deeply intertwined with human culture, providing nourishment, beauty and economic opportunities. In an era marked by climate change, resource depletion and global food insecurity. Horticulture emerges as a beacon of hope. Imagine a world where every backyard, terrace and vacant urban lot transforms into a green haven. This Vision isn't just a dream it's the promise of horticulture. By empowering individuals and communities to cultivate fresh, nutritious crops, we can create a sustainable and self-reliant future.

### The Power of Green

### Why Horticulture Matters

**Feeding the World with Diversity:** Horticulture offers a kaleidoscope of fruits, vegetables and herbs that cater to diverse nutritional needs. These crops are rich in essential vitamins and minerals, combating malnutrition and boosting immunity. Unlike monoculture farming, which focuses on a single crop, horticulture promotes biodiversity, reducing the risk of food scarcity and crop failures.

**A Boxt to Rural Livelihoods:** In rural areas, horticulture is a lifeline. From smallholder farmers selling mangoes in local markets to florists creating vibrant bouquets, horticulture generates income across the value chain. High-value crops like strawberries, exotic flowers and medicinal plants fetch premium prices, empowering farmers to break free from poverty.

### Cultivating Sustainability

**Goodbye Chemicals, Hello Nature:** Sustainable horticulture emphasizes working with nature, not against it. By avoiding harmful chemical fertilizers and pesticides handed by the Government of India, farmers can protect both their crops and the environment. Instead, organic fertilizers like vermicompost and bio-pesticides derived from neem and garlic are gaining popularity.

**Water-Wise Gardening:** Water scarcity is a growing concern, but horticulture offers solutions. Techniques like drip irrigation and Rainwater harvesting ensure that every drop counts. Urban farmers are embracing hydroponics growing plants without soil using 90% less water than traditional methods.

**Restoring Soil:** The Foundation of Life
Soil isn't just dirt; it's a living ecosystem that supports life. Over the years, excessive use of chemical inputs has degraded soil fertility. Horticulture rejuvenates soil through practices like:

**Green Manuring:** Planting cover crops like legumes to enrich the soil with nitrogen.

**Mulching:** Covering soil with organic matter to conserve moisture and prevent erosion.

**Crop Rotation:** Breaking pest cycles and maintaining soil nutrients by alternating crops.

Healthy soil equals healthy plants, which in turn leads to healthy communities.

**Horticulture: A Climate Warrior**

**Fighting Climate Change, One Plant at a Time:** Plants are natures best carbon absorbers. By integrating trees, shrubs and crops, horticulture acts as a natural carbon sink, reducing greenhouse gases. Climate-resilient varieties like drought-tolerant tomatoes and lood-resistant hananas ensure productivity even in extreme weather conditions.

**Urban Oasis:** Cities are transforming into urban jungles, but not the kind we need. Rooftop gardens, vertical farms and community parks powered by horticulture are bringing back greenery to concrete landscapes. These spaces not only cool the environment but also promote mental well-being.

**Beyond Farming: The Therapeutic Touch of Horticulture**

Horticulture is more than a livelihood its therapy. Known as horticulture therapy, tending to plants has proven benefits for mental health. From veterans overcoming trauma to children learning patience, gardening heals the mind and soul. This practice is now being adopted in hospitals, rehabilitation centers and schools worldwide.

**Economic Empowerment through Innovation**

**Agri-Entrepreneurs on the Rise:** With the advent of technology, young entrepreneurs are revolutionizing horticulture. Start-ups are innovating with precision farming, drone-based crop monitoring. And AI-powered market analysis. These advancements are making horticulture more profitable and appealing to the youth.

**Value Addition and Export Opportunities:** Raw produce often fetches lower prices. But value addition can change that. Processing fruits into jams, drying herbs, or packaging vegetables attract higher profits. Indian horticultural products, like Alphonso mangoes and Kashmiri saffron, have a global market, boosting foreign exchange earnings.

**Conclusion**

Horticulture is not just about cultivating plants it's about cultivating possibilities. From battling malnutrition to tackling unemployment, horticulture holds the key to a sustainable and prosperous future. By embracing eco-friendly practices and harnessing innovation, we can transform horticulture into a movement of hope. Let us sow the seeds today for a greener, healthier and more resilient tomorrow.

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**For the welfare of the Farmer's, the society "Society for Advancement in Agriculture, Horticulture and Allied Sectors" willing to publish E-magazine in the name of "Krishi Udyan Darpan E-Magazine** (Hindi) / **Krishi Udyan Darpan** E-Magazine (English**, Innovative Sustainable Farming**.)**, which covers across India.**

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15. Submitted manuscript are only running article and contains the field of Agriculture, Horticulture and Allied sectors.
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# ABOUT THE SOCIETY

Father of Nation Mahatma Gandhi's concept of rural development meant self-reliance, and least dependence on outsiders. India is an agrarian country and about 65% of our population lives in rural areas. But unfortunately, most of us do not have any idea about the extent of poverty and the real conditions of rural India.

With the purpose of serving the agricultural fraternity and farming community the Society for Advancement in Agriculture, Horticulture and Allied Sectors (SAAHAS) was founded in 2020 (under Society Registration Act, 1860). Among multifarious ways of serving farming community we are involved in training of the farmers by organising technology dissemination programmes in villages, guiding them to adopt good agricultural practices involving planned crop management. It helps in reducing farm base losses and motivating them to become farmer level entrepreneur rather than a simple producer. It involves initiating skill based knowledge to the student of agriculture, horticulture and allied sectors to encourage them to serve the farmers in the best possible ways.

SAAHAS calls us to look into the genuine problems of farmers and address those issues for their betterment in the arena of Agriculture, horticulture and allied sectors. Besides agriculture, horticultural crop production has been given a major focus by Govt. of India in future crop diversification, improving livelihood through doubling farmers' income, economic opportunities through export and job opportunities. While good beginning is made, much is to be achieved in different areas in agro-horticulture sector.

Apart from that, SAAHAS helps developing the culture to involve more number of women in farming, processing of crops and value addition thereof for higher returns in terms of total income. SAAHAS eagerly involves with the farmers and agriculture entrepreneur to motivate them for introducing hi-tech farming, which includes growing of high value horticultural crops in hydroponics, aeroponics, polyhouse, net house and greenhouse. The society has geared up its activities to take up the challenges of biotic and abiotic stresses, emerging needs of quality seeds and planting material and reducing cost of production.

There are several government and non-government organisations intended of farmer's welfare; still there is dire need for more involvement and attachment with the farmers. Our society's noble initiative can ensure diminishing of the persistent gap between agro-technocrats, scientists with the needy farmers. We not only ensure that the farmers choose right variety of right crop, better nutrient management through diagnosis recommended system and pest diagnosis but we also help them to sale their produce at premium rates. There is a major issue of chemical residues in food, soil and ecology which is also a big concern of the century. The Society also aims to motivate the farmers either for minimal use of chemical inputs or total adoption of organic farming. Consultancy, training, awareness programs, national and international seminars and symposia and technical services are the prime activities of the SAAHAS.

Society for advancement in Agriculture, Horticulture and Allied Sectors publishes peer reviewed scientific journal, 'Journal of Applied Agriculture and Life Sciences (JAALS)', biannually since January 2020 focusing on articles, research papers and short communications of both basic and applied aspect of original research in all branches of Agriculture, horticulture and other allied sciences. To apprise the scientists and all those who are working in the field of Agriculture, horticulture and allied sectors about recent scientific advancement is the aim of the Journal.