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HI-TECH HORTICULTURE: A WAY FORWARD

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Abstract

Horticulture is a rapidly growing sector with significant potential to drive economic growth, job creation, and nutritional security. Hi-tech horticulture leverages advanced technologies such as micropropagation, micro irrigation, precision farming, hydroponics, greenhouse cultivation, and remote sensing to optimize crop production, quality, and resource efficiency. High-density planting, integrated pest and nutrient management, and plasticulture are among the techniques that increase yield and profitability while reducing environmental impact. Remote sensing plays a crucial role in crop management, enabling accurate monitoring of crop conditions, canopy volume, yield estimation, and pest and disease detection. The integration of these modern techniques provides substantial opportunities for enhancing productivity and meeting the growing demand for high-quality horticultural products.

Introduction

Horticulture has become one of the agricultural industries with the ability to boost economic growth over time. Its contribution to the nation's initiatives for job creation, poverty reduction, and nutritional security is growing in significance. In addition to giving farmers many alternatives for crop diversification, it also offers plenty of room to support numerous agro-industries that create a significant number of job possibilities. In comparison to other agronomic crops, the horticultural sector offers a significant deal of opportunity for the application of high technology because it may be grown on a smaller land area with greater yield, particularly for vegetable, flower, and medicinal crops. Any modern technology that is less reliant on the environment, requires less money, and has the potential to increase the yield and quality of horticultural crops can be used in "high-tech horticulture". In order to manage and produce high-quality horticultural products for high economic returns, hi-tech horticulture uses advanced technologies such as micropropagation, micro irrigation, fertigation, hydroponics, precision farming, high density planting, integrated pest management, integrated nutrient management, hybrid seeds, genetically modified planting materials, protected cultivation (polyhouse and greenhouse, etc.), plasticulture, use of bio inputs, remote sensing, use of GIS in horticulture, advanced mechanisation, etc. Because they can be grown in greenhouses, vegetables play a great role in high-tech horticulture and are a perfect fit for this technology. High-tech horticulture for vegetable crops has been transformed by the use of portray and rooting media.

Importance and Scope of Hi-Tech Horticulture

1. Manufacturing high-quality fruits, vegetables, flowers, and goods with added value.
2. High-tech horticulture technology can be used to increase productivity per unit area.
3. Greater revenue or a larger return
4. Using biotechnologies to extend crop shelf life. For example, applying Genetic

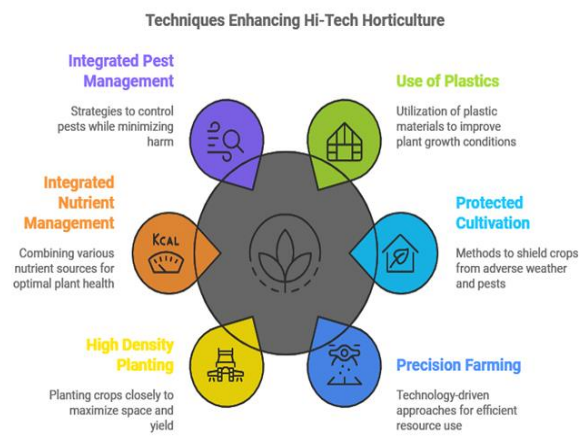
Modified Technologies (GM) to crops like tomatoes and capsicum has significantly extended their shelf life.

5. Using biotechnologies to manage diseases and pests
6. True-to-type, high-quality, and disease-free planting materials, like bananas, are now available thanks to tissue culture technology.
7. Fertigation method for effective nutrient usage
8. Water efficiency through the use of subterranean irrigation systems and drip irrigation
9. Hydroponics use Higher vegetable crop yields can be achieved with the use of water, nutrients, and other soilless media technology, or hydroponics.
10. Using plasticulture technology to control weeds in the production of horticulture crops.
11. High density planting technology has improved growers' production and profitability in fruit, plantation, spice, vegetable, and flower crops.
12. Hi-tech technology can be used to generate high-quality exports of horticulture crops, such as tomatoes, cucumbers, roses, carnations, gerberas, planting materials, and capsicums.
13. Protected culture method can be used to successfully harden planting material.
14. There is enormous potential for high-tech horticultural production through government supports for constructing green houses, irrigation systems and advanced machinery for advanced mechanisation.
15. Export-quality horticultural products are in high demand both domestically and internationally.

Benefits of Hi-Tech Horticulture

1. High output.
2. Preserving important contributions such as fertilisers (25%) and insecticides, fungicides, herbicides, and water (up to 50%).
3. Generates better, more reliable outcomes.
4. This is possible in hilly, sandy, and uneven terrain as well as troublesome soil types including saline or waterlogged soil (NABARD, 2019).
5. The crops may be grown all year round and will be less reliant on the environment.

Segments of Hi-Tech Horticulture



Micro Irrigation System

Modern irrigation techniques include micro irrigation, which uses emitters on the surface or beneath the ground to irrigate water using drippers, sprinklers, foggers, and other devices.

Types of Micro Irrigation Systems

The newest commercial water application technique is drip or trickle irrigation. Water is applied to soils often and slowly using mechanical devices known as emitters or applicators that are positioned at specific spots along the delivery lines.

1.Spray-irrigation

The Spray-irrigation is a method where plants are sprayed with pressurised water to provide them water. Sprinkler irrigation is another name for this kind of irrigation, which is utilised extensively worldwide.

Every size farm can benefit from the spray irrigation sizes, which range from industrial-sized sprinklers used to irrigate crops to residential sprinklers used to maintain a lush lawn.

2.Sub-Surface System

This technique uses emitters to gradually apply water beneath the surface of the land. Semi-permanent and permanent installations typically favour such systems. The low-pressure, high-efficiency irrigation method known as subsurface drip irrigation (SDI) employs drip tape or buried drip tubes to supply agricultural water. Irrigated agriculture has been using SDI technologies since the 1960s, and for the past 20 years, the technology has advanced quickly.

3.Bubbler System

This method uses a small stream or fountain to deliver water to the soil surface. Point source bubbler emitters typically have a discharge rate below 225 liters per hour, which is higher than that of drip or subsurface emitters. Because the emitter's discharge rate usually exceeds the soil's infiltration rate, a small basin is often needed to retain or manage the water. Bubbler systems do not require complex filtration, making them suitable for irrigating trees with extensive root zones and high water demands, or for situations where a large volume of water needs to be applied quickly.

Use of Plastics

There are several uses for plastics in commercial horticulture. "Plasticulture" refers to the use of plastics in commercial horticultural production. Horticultural products is always produced and handled with plastic after harvest. Off-season cultivation, mulching, micro-irrigation, propagation, packaging, green house, net roof top gardening, etc. Nowadays, plasticulture is a widely used high-tech horticultural technique. Plastic mulch, plastic lining, and protected cultivation (greenhouse structures, high and low tunnels, etc.) are some of the many uses of plastics in horticulture. Plasticulture enhances the financial efficiency of industrial processes and aids in the effective management of energy and water resources. In addition to helping to prevent insect and disease infestations, plasticulture lowers temperature and moisture changes. Because plasticulture reduces soil erosion and water and nutrient waste, it is essential for accurate irrigation and nutrient treatments. Utilising plastics has helped to encourage the wise use of natural resources such as soil, water, sunlight, and temperature.

High Density Planting

HDP is a planting strategy that accommodates more plants per unit area than is often used. Early in the 1960s, a successful attempt was made in Europe to establish apple plantations using dwarfing rootstocks. In addition to Europe, Australia, America, Japan, New Zealand, and Israel all use HDP commercially to cultivate temperate fruit crops. Given the current situation, where the land-to-man ratio is drastically dropping, HDP needs to gain the support it deserves. High production per unit area is provided by HDP for both short-term and long-term horticultural crops.

HDP of Apple

Today, agricultural labor is both scarce and inexpensive, driving the need for mechanization. To ensure timely completion of farm operations, a range of tasks must be automated. Machines can be used for various activities, including digging planting pits, applying fertilizers, spraying chemicals, weeding, training and pruning plants, micro-irrigation, harvesting, sorting, grading, waxing, packaging, and value addition.

Apple Grading Machine

Spraying in grape

Hydroponics

This method uses mineral fertiliser solutions in an aqueous solvent to grow plants in water. Another cutting-edge horticultural technology that provides horticultural growers all over the world a lot of opportunities is hydroponics. Another name for hydroponics is soilless cultivation. Without the use of conventional soil medium, hydroponics enables growers to cultivate plants in nutrient solution.

Aeroponics

Plants growing under air or mist conditions is referred as aeroponics. The technique was no utilization of soil and using nutrients in the form of mist or air directly to the root zone of the plants.

Hydroponics

Aeroponics

Integrated Pest Management (IPM)

Nowadays, IPM, is a common high-tech horticultural technique. One of the most important prerequisites for advancing sustainable agriculture and rural development in horticulture production is integrated pest management. The goal of integrated pest management is the prudent application of chemical, biological, and cultural methods to control illnesses and pests.

Integrated Nutrient Management (INM)

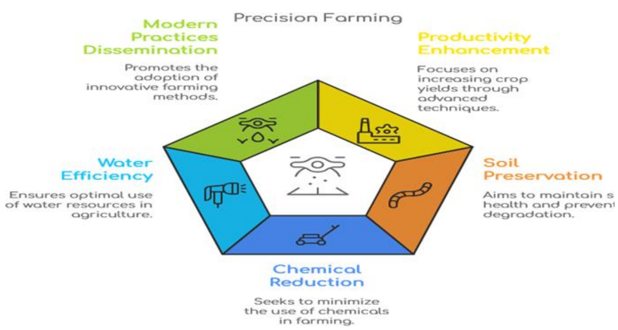
Nowadays, integrated nutrient management, or INM, is another popular high-tech horticultural technique. By maximising the advantages of all potential plant nutrient sources in a coordinated way, INM, aims to maintain soil fertility and plant nutrient delivery at an optimal level for maintaining the targeted crop yield. Enhancing fertiliser usage efficiency (FUE) by strategically placing fertiliser in the rhizosphere with the maximum root activity is another crucial component of INM. Integrated Nutrient Management is already a standard technique among forward-thinking horticulturists.

Precision Farming

Precision farming, or precision agriculture, aims to take the right action at the right time, in the right place, and in the right way. It involves managing inputs such as water, seeds, and fertilizers to maximize yield, quality, and profitability while reducing waste and promoting environmental sustainability. By aligning agricultural practices with crop needs and local agroclimatic conditions, precision farming enhances the accuracy of input applications. The approach leverages high-tech, location-specific interventions, including fertigation, protected or greenhouse cultivation, in-situ moisture conservation through mulching, micro-propagation, high-density planting, drip irrigation, and nutrient-based fertilization guided by soil and leaf analysis. Precision farming integrates crop management technologies like GIS, GPS, and remote sensing (RS) with ground-based equipment such as variable rate applicators

(VRA), yield monitors, and computer software, ensuring efficient resource use. Ultimately, precision agriculture aims to transform the agricultural system towards low-input, high-efficiency, and sustainable practices by combining environmental health, economic viability, and social equity.

Objectives



Greenhouse Cultivation

Nowadays, contemporary horticultural producers are big fans of greenhouse or sheltered growing. Horticultural items, primarily under protected cultivation horticultural crops are more efficient and can be produced off-seasons due to this high-tech horticulture technology, which has various advantages over traditional production methods.

Remote Sensing Techniques in Horticulture

In India, fruits and vegetables account for about 90% of horticultural production. As of 2015, the country is the world's second-largest producer of these crops, leading in items like cashew nuts, areca nuts, papayas, mangoes, bananas, and okra (National Horticulture Board). Horticultural crops, including fruits, vegetables, spices, medicinal plants, and plantation crops, contribute significantly to crop value and ensure nutritional security. To systematically manage existing crops and expand horticulture acreage, a robust database is essential for planning and decision-making. Remote sensing is a proven tool for this purpose. It involves collecting data about objects or areas from a distance, typically using satellites or aircraft, by measuring reflected and emitted radiation. Remote sensing systems consist of four key components: the target, the energy source, the transmission path, and the satellite sensor. Sensors aboard satellites or aircraft detect electromagnetic radiation, allowing for the classification of Earth's landforms and features. Passive remote sensing relies on sunlight reflection, while active remote sensing involves the sensor emitting signals and detecting their reflections. This technology is crucial for estimating crop areas, mapping, and classifying land use, covering vegetation, soil, water, forests, and human activities.

Applications in horticulture

1. **Crop Insurance:** Insurance companies can use satellite imagery's red and infrared bands, along with the Normalized Difference Vegetation Index (NDVI), to assess seeded fields and detect potential fraud.

2. **Crop Stand Identification:** Remote sensing is highly effective for identifying crop stands, helping to determine the total area under cultivation and assess productivity.

3. **Crop Condition Monitoring:** Remote sensing, using NDVI, can assess crop health by detecting near-infrared radiation, which indicates healthy vegetation in horticulture.

4. **Estimating Crop Area:** Horticultural crops often experience large fluctuations in production and consumption, leading to market volatility. Accurate data on

production and acreage are essential for export planning and market stability. Remote sensing plays a key role in evaluating crop supply.

5. **Crop Canopy Measurement:** Canopy volume is critical for determining the appropriate amounts of fertilizers, pesticides, and other chemicals. It also provides insights into expected yield and crop health, which can be measured effectively through remote sensing techniques.

6. **Yield Estimation:** While remote sensing is widely used for estimating yields of annual crops, its application to fruit trees and vegetables has been limited.

Pests and diseases are major factors affecting horticultural output and financial losses. Remote sensing can be a valuable tool for managing these issues by detecting changes in plant pigments, leaf damage from insects, and identifying vulnerable areas for early disease and pest management.

Conclusion

Hi-tech horticulture presents a promising approach to transforming traditional agricultural practices into a more efficient, sustainable, and high-yielding system. By adopting advanced technologies, such as remote sensing and greenhouse cultivation, horticultural production can be optimized for higher output and better quality, even in challenging environments. The adoption of precision farming and other hi-tech methods enhances resource use efficiency, addressing challenges such as water scarcity, labor shortages, and market volatility. Overall, the application of these technologies offers substantial benefits for economic growth, export potential, and sustainable development in the horticultural sector.

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