

Hitech Cultivation-A Boom in Horticulture Crops

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Abstract: Horticulture is a growing sector with significant capacity to drive economic growth, generate employment, and improve nutritional security. Hitech horticulture employs advanced technologies such as micropropagation, micro irrigation, precision farming, hydroponics, greenhouse cultivation, and remote sensing to improve crop yield, quality, and resource efficiency. Techniques such as high-density planting, integrated pest management, nutrient management, and plasticulture improve yield and profitability while reducing environmental impacts. Other beneficial technologies such as Remote Sensing are crucial for crop management, enabling accurate monitoring of crop health, canopy dimensions, yield forecasting, and detection of pests and diseases. The integration of these modern techniques presents substantial opportunities to enhance productivity and meet the growing demand for high-quality horticultural products. The integration of cutting-edge technology has become vital for enhanced productivity. The incorporation of Artificial Intelligence (AI) into advanced horticulture is becoming a groundbreaking advancement in contemporary agricultural practices. This review article focuses on recent farming techniques and cutting-edge technologies, discussing their advantages and disadvantages in detail.

Key Words: AI applications, Hi-Tech horticulture; Precision agriculture, Smart horticulture farming. Advanced technologies, yield and productivity.

Introduction

Horticulture has become one of the agricultural fields that can promote economic growth over time. Its significance in the nation's initiatives for creating jobs, reducing poverty, and ensuring nutritional security is growing more prominent. In addition to offering farmers different choices for crop diversification, it creates significant opportunities to foster multiple agro-industries that produce a substantial number of job prospects. Compared to other agricultural crops, the horticulture sector offers significant chances for advanced technology use, as it can be grown on reduced land while producing greater yields, especially for vegetables, flowers, and medicinal plants. Any modern technology that relies less on the environment, requires less investment, and can improve the yield and quality of horticultural crops can be employed in "high-tech horticulture." Integrated nutrient management, hybrid seeds, genetically modified planting materials, protected cultivation, plasticulture, and the use of potting and rooting media have transformed high-tech horticulture for vegetable production. (S.K. Malhotra, 2017)

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Enhancing access to healthy planting materials of improved or recommended varieties, backed by a network of regional nurseries with distribution capabilities, will aid in the scientific advancement of horticulture.

Rise in cultivation of horticulture crops

Horticulture has emerged as an essential part of agriculture, progressing through various phases, covering around 24.3 million hectares, and producing an annual output of 299 million tons (2016-17). This sector encompasses diverse crops such as mushrooms, tuber varieties, root, vegetables, and ornamental flowers, nuts, medicinal and aromatic plants, and plantation crops like oil palm and coconut, cultivated in various agro-climatic zones. The variation in area and output clearly shows that the rise in production results from both an enlargement of area and an enhancement in productivity. Even though these crops cover just 14% of the cultivated land, they account for more than 32% of the nation's total agricultural output. Fruits and vegetables serve as prominent sources of nutrients and carbohydrates, vital for biological nourishment. Consequently, these are stated to as vitamin rich foods and shows a key role in all individuals with a well-being nutritional aspect. Consequently, the cultivation of horticultural crops is vital for a country's prosperity and is significantly tied to the happiness and welfare of its people. Emphasizing horticulture highlights the importance of attaining nutritional security and guaranteeing a sustainable livelihood. Improved nutrition will boost children's learning capacity and adults' productivity, leading to higher incomes and a reduction in poverty levels. (Maqbool, A., *et al.*, 2024)

Production Changes through Hitech horticulture

Fruits produce greater amounts of food per hectare than cereals. For instance, the maximum yield of paddy is 3 tonnes per hectare, while it is 22 tonnes per hectare for banana, 45 tonnes per hectare for pineapple and 40 tonnes per hectare for grapes. Significantly less land is needed to meet the annual calorific needs per adult (11,00,000 kcal) through cultivating banana (0.03 hectare) or mango (0.16 hectare) compared to growing wheat (0.44 hectare). Horticultural crops overall are low in protein since they have under 2% protein content. Fruits provide a significant supply of organic acids such as citric acid in citrus fruits and tartaric acid in grapes, which enhance appetite and aid digestion. Papaya has enzymes that digest proteins. Numerous fruits and vegetables have laxative effects because of the dietary fibre and pectin they contain, which promote intestinal movement. Micronutrient malnutrition, caused by poverty, poses a risk to at-risk populations in the Asian and Pacific areas. This appears as a deficiency in vitamin A, iron deficiency anaemia, and disorders related to iodine deficiency. The initial two could be reduced, as previously mentioned, via horticultural efforts and awareness campaigns. (Reddy, P.P., 2024)

Advances in Hitech horticulture practices

Technological progress in horticulture today includes heterogeneity and marketing. This encompasses the adoption of desirable diversity, a higher proportion of horticultural crops in agricultural practices, and a shift towards processing and export-oriented production for many crops as the key recent changes observed. Numerous technological advancements have been made across the entire value chain, including skill for plantation development, access to homogenous planting material, plant architecture engineering and management, mulching, fruit thinning, integrated nutrient management, water management, integrated pest and disease management, post-harvest technology, processing, and marketing. The positive developments in the horticulture sector have taken place due to the recognition of its significance by all stakeholders, including the public sector, private sector, and farmers over the

past ten years. This mainly stems from the recognition that diversifying into horticultural crops is currently the key strategy to enhance livelihood security and healthcare. (Prakash S., *et al.*,2023)

Systems of cropping patterns

An approach focusing on horticulture-based cropping systems for the sustainable utilization of farm resources and diminished risks has been effectively showcased in perennial horticulture. Various farming system models have been created, and appropriate crops for the initial years of tree planting to optimize output in diverse agro-climatic conditions have also been established. Medicinal and aromatic crops that thrive in shade, such as Aromatic Ginger, *Pelargonium graveolens* (Sweet scented geranium), Indian snakeroot(*sarpagandha*), *Pogostemon patchouli* and *Piper longum* (long pepper), are effectively cultivated under *Areca catechu* (areca nut) and *Cocos nucifera* (coconut trees). The decision on which crops to select primarily depends on the grower's requirements. The *Amorphophallus paeoniifolius* (yam) is commonly cultivated as an intercrop in *Musa acuminata* (banana), *Litchi chinensis* (litchi), and coconut plantations. Spices such as *Piper nigrum* (black pepper), *Zingiber officinale* (ginger), *Curcuma longa*(turmeric), *Vanilla planifolia*(vanilla), *Myristica fragrans* (nutmeg), *Syzygium aromaticum*(clove), and certain medicinal plants are perfect as intercrops for coconut. Thoughtful choice of enterprises with optimal distribution of resources in the agricultural system fosters competitive dynamism, cost efficiency, and effectiveness by boosting input efficacy, increasing genetic productivity, and leveraging the synergies of enterprises. (Dhanaraju M., *et al.*,2022).

Applications of hi-tech horticulture

In contrast, Precision Agriculture involves applying knowledge and principles to tackle spatial and temporal variability associated with all aspects of horticultural production to improve grown produce and environmental standards. Precision agriculture requires effective resource management via location-based high-tech solutions. Advanced horticulture includes numerous practices like drip irrigation, nutrigration, conservatory and glass house cultivation, for soil and leaves, mulching to conserve moisture, micro propagation, germplasm biotechnology, genetically engineered crops, biofertilizer usage, Vermicomposting, Intensive planting, Smart farm machinery, green food production, biological pest control and Hydroponics. The use of nutrients via precision agriculture has proven to be more lucrative than conventional package suggestions. Initiatives such as greenhouse building, mulching, shade nets, and plastic tunnels are also being encouraged. The crops where certain elements of precision farming have been utilized include *Musa paradisiaca*(banana), *Vitis vinifera* (grape), *Punica granatum*(pomegranate), *Capsicum annuum*(capsicum), *Solanum lycopersicon*(tomato), *Capsicum annuum*(chili), *Anacardium occidentale*(cashew), and specific flowers (Malhotra, S.K., Srivastava, A.K.,2017).

AI in Hitech horticulture

AI technologies—covering precision agriculture, machine learning, big data analysis, robotics, and the Internet of Things (IoT)—are greatly improving productivity, efficiency in operations, and sustainability in horticultural practices. Utilizing AI-driven decision support systems and autonomous technologies facilitates immediate, data-informed decision-making, enhancing input efficiency and minimizing environmental effects. Moreover, AI helps tackle issues related to labour shortages, climate fluctuations, and quality control, aiding in reducing crop losses and promoting greater profitability and food safety. Despite clear advantages, the extensive use of AI in horticulture is obstructed by obstacles like low farmer awareness, elevated implementation expenses, and data limitations. In the end, AI serves

as a crucial instrument in transforming high-tech horticulture, promoting robust, effective, and sustainable agricultural-horticultural systems for the future. (Singh, B., *et al.*,2024).

Constraints

The integration of artificial-intelligence solutions in horticulture faces several significant challenges that collectively hinder widespread adoption. The primary issue is that producers have limited access to and understanding of digital intelligence platforms, a gap that amplifies the knowledge divide and obstructs the effective integration of AI-powered tools. Financial factors pose another significant challenge: The generation, annotation, and curation of the necessary data pools require considerable time, effort, and specialized expertise, thus increasing the complexity of implementation. Together, these interconnected challenges slow down the integration of AI into horticultural systems, despite the technology's potential to revolutionize the field. (Haokip, S.W.,2022).

Future outlook

As climate instability undermines conventional agriculture and the global population increases, artificial intelligence provides a practical solution to bolstering global food security. Strategic implementation of AI in agriculture and horticulture aims to improve planting schedules, maximize resource utilization, and reduce post-harvest waste.

Conclusion

As per capita income rises and a health-minded people grows, the mandate for horticultural products is increasing and is anticipated to continue rising, necessitating greater production. However, the production must remain competitive regarding both quality and cost. Consequently, the capabilities that are present must be utilized, and benefits need to be maintained. Creation of enhanced varieties featuring superior quality traits, increased yield, resilience to pathological, entomological and resistance to environmental distress. Therefore, horticultural development should be regarded as a cohesive strategy, tackling significant gaps by leveraging potential through focused research aimed at improving efficiency. As a result, technology-based horticulture is anticipated to tackle the issues of supplemental and nutritional safety, health services, ultimately resulting in economic progress. In the future, research must focus on enhancing algorithmic models, expanding affordable access for small-holder producers, and thoroughly tackling ethical and governance issues to guarantee that the advantages of these innovations are shared fairly. In essence, AI functions as a revolutionary agent, redefining horticultural frameworks and paving the way for a more robust, fruitful, and efficient agricultural-horticultural tomorrow.

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