**Fruit Production and Enhancing Farmers Income**

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**Introduction**

India has a diverse climate that allows for the production of various fresh fruits, ranging from tropical to temperate. According to the National Horticulture Database (3rd Advance Estimates) published by the National Horticulture Board, India was the second largest producer of fruits in the world, after China, in 2021-22, with a total output of 107.24 million metric tonnes. The area under fruit cultivation was 11.35 million hectares. [**According to the FAO Statistical Yearbook 2021**](https://www.fao.org/3/cb4477en/online/cb4477en.html)**, the total fruit production in the world in 2021 was estimated at 913.6 million tonnes.** India has a prominent role in the global fruit industry, as it accounts for 11.73% of the total fruit output in the world. The country has a diverse range of climatic conditions and soil types that enable it to grow a variety of fruits throughout the year. Horticulture is seen as optimal option for crop diversification in agricultural sectors that face challenges such as climate change, land degradation, and market fluctuations. The per unit land earning capacity of farmers is much more than in case of food grains and it also addresses environmental concerns. Despite these challenges, horticulture remains a vital source of income and nutrition for many farmers and consumers. However, to increase the profitability and sustainability of this sector, it is essential to overcome the barriers that limit the access and quality of market linkages, post-harvest infrastructure and connectivity. These are the key factors that determine the value addition and competitiveness of horticultural products.

According to the data from the Ministry of Agriculture and Farmers Welfare, banana was the most produced fruit in India in 2022, with a total production of 32.1 million metric tons. It was followed by mango, which had a production of 20.6 million metric tons, and citrus, which had a production of 13.3 million metric tons. These three fruits accounted for more than 70% of the total fruit production in India in 2022. According to the Food and Agriculture Organization of the United Nations, India ranked first in the world in the production of bananas, mangoes, and papayas in 2019, with 26.4%, 43.8%, and 39.3% of the global output, respectively. India also contributed significantly to the global production of other fruits, such as guava, apple, pineapple, grape, pomegranate, sapota, and litchi.

The fruit production in India was dominated by seven states in 2022. These were Andhra Pradesh, Maharashtra, Madhya Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka and Gujarat. Andhra Pradesh was the top fruit producer in the country, with 19 million metric tons of fruits in 2022. Maharashtra followed with 12.4 million metric tons of fruits in the same year. **India was a leading producer of fresh fruits with a production share of 11.73% globally. However, its export share was only 0.5%, indicating a huge gap between potential and performance. India exported fresh fruits worth Rs. 6,219.46 crores/ 770.70 USD Millions in that year, mainly to UAE, Bangladesh, Nepal, Malaysia, Netherland, Sri Lanka, U.K., Qatar, Oman, and Iraq. The most popular fruits exported from India were grapes, pomegranates, mangoes, bananas, and oranges.**

India has a diverse range of climate and soil conditions that allow it to grow many kinds of tropical, subtropical, and temperate fruits. Horticulture is a rapidly growing sector in agriculture that helps reduce poverty, improve nutrition, and create more income and employment opportunities for farmers and agro-based industries. Presently horticulture contributes 33 per cent of agricultural gross domestic products (GDP). To achieve the national goal of 4.0 per cent growth in agriculture, horticulture plays a vital role. Horticulture is well suited for India's topography and agro climate, which became evident after the Green Revolution in the mid-sixties. The most significant development that happened in last decade is that horticulture has moved from rural confines to commercial production and this changing scenario has encouraged private sector investment in production system management. The last decade has seen technological infusion like micro-irrigation, precision farming, greenhouse cultivation, and improved post harvest management impacting the development, but they have also raised various challenges.

One of the main challenges in exporting fresh fruits from India is the low productivity (cost competitiveness) compared to the global standards. This is due to the lack of advanced pre-harvest and post-harvest technologies, as well as the international quality standards. Moreover, the market channels are distorted and do not facilitate efficient trade. Therefore, there is a need for a paradigm shift in this sector to achieve a better balance between production and other sub-systems, such as pre-harvest technologies, post-harvest processing, quality management, export infrastructure, supply chain, market information and marketing strategies.

**Fruit production limitation**

During the years, productivity and quality of many horticultural crops have continued to remain much below the potential, demonstrated in research trials. There are various factors, which contribute to low productivity. They are:

**1. Low productivity of crops due to**

* Poor quality planting materials of improved cultivars, inferior genetic stocks and poor management.
* Lack of mechanism for assessing quality of planting materials.
* High risk of transmission of virus diseases from one generation to other, in propagated materials.
* Predominance of old and senile orchards which needs replacement / rejuvenation.
* Vast majority of holdings are small and rainfed.
* Unawareness about the Hi-technology, poor capacity of farmers to invest and poor credit support coupled with problems of infrastructure.
* Lack of knowledge on seasonal growing to meet the export demands.

**2. Inferior fruit quality due to**

* Poor post-harvest management practices.
* Absence of infrastructural facilities for handling and storage.
* Absence of efficient marketing system coupled with seasonality and perishability.
* Weak processing infrastructures.
* Lack of adequate standards for quality produce.
* High capital investment hinders effective utilization of raw materials.

3.The high capital costinvolved in establishing an orchard as also setting up of necessary infrastructure is a serious constraint in expansion of area under many horticultural crops as well as improvement in existing orchards.

5. A reliable and comprehensive database is essential for horticultural development planning in the long term. Otherwise, the planning process will face difficulties and lack realism.

6. One of the major challenges faced by fruit growers is the high incidence of pests and diseases attack. Pests and diseases can reduce the yield and quality of fruits, as well as increase the cost of production and post-harvest losses.

7. Chronic production problems due to major disorders like alternate bearing, malformation and spongy tissue in mango, guava wilt, citrus decline, *Phytophthora* diseases in large number of crops etc. remain largely unresolved.

8. Lack of technologies for the improvement in wastelands and hilly terrains being the potential future expansion areas.

9. Less improved technologies for the large scale production of underutilized crops which are best suited for wastelands, and poor and marginal soils.

**Future strategies for improved crop production technologies for augmenting production, productivity and quality**

1. **GIS in horticulture:**

Remote sensing and geographic information system technologies have been of great use to planners in planning for efficient use of natural resources at national and regional levels. Application of these technologies in the management of natural resources are increasing rapidly due to great strides made in space borne remote sensing satellites in terms of spatial, temporal, spectral and radiometric resolutions.

Modern management of agricultural resources is a complex endeavor that is now benefiting from a convergence of technical advances in information sciences, geographic positioning capabilities, and remote sensing systems. Translation of remote sensing GIS techniques and horticultural farming database information in to implementable schemes at the field level and absorption of technology at the grass root level by the actual beneficiaries still remains a greater challenge. These technologies should infiltrate in to agricultural and horticultural sector at micro level for greater and sustainable benefits.

Horticulture crops are an important source of income and nutrition for many farmers and consumers around the world. However, they also face many challenges such as pests, diseases, climate change, water scarcity, and market fluctuations. To overcome these challenges and increase production, horticulture farmers can benefit from using geographic information system (GIS) technology. GIS is a tool that allows users to collect, store, analyze, and visualize spatial data related to horticulture crops. GIS can help horticulture farmers in various ways, such as:

* Mapping and monitoring crop areas, yields, and quality using satellite imagery, drones, sensors, and GPS devices.
* Identifying optimal locations and conditions for planting, irrigating, fertilizing, and harvesting crops using spatial analysis and modeling techniques.
* Detecting and managing pest and disease outbreaks using remote sensing and geospatial intelligence.
* Assessing and reducing environmental impacts of horticulture practices using spatial indicators and sustainability metrics.
* Enhancing market access and competitiveness of horticulture products using geospatial marketing and traceability systems.

GIS technology can thus provide horticulture farmers with valuable information and insights that can help them improve their decision-making, productivity, profitability, and resilience. By adopting GIS technology, horticulture farmers can contribute to achieving the Sustainable Development Goals of ending hunger, ensuring food security, promoting sustainable agriculture, and conserving natural resources.

1. **Safeguard for intellectual property rights (IPR):**

The exchange of plant genetic resources is a crucial aspect of horticultural research and development. However, there are many challenges and risks involved in this process, such as intellectual property rights, biosafety, quality standards, and phytosanitary measures. To address these issues, a comprehensive and transparent system of varieties registration, material transfer agreement, and germplasm distribution needs to be established and implemented. Furthermore, the export potential of indigenous fruits and vegetables depends on the adherence to international quality and codex standards, which need to be developed and harmonized with the global market requirements. Finally, the import of vegetatively propagated materials poses a threat to the domestic plant health and biodiversity, which requires a careful review and revision of the existing phytosanitary regulations and their strict enforcement.

1. **Diversifying fruit crops and products**:

Diversification of fruit crops and products is a key strategy for fruit farmers to enhance their resilience, profitability, and market access. By cultivating a variety of fruits that have different harvesting seasons, nutritional and medicinal benefits, and value addition potential, fruit farmers can reduce their exposure to climatic and market shocks, increase their income sources, and cater to the needs of diverse consumers. Some of the value-added products that fruit farmers can produce from their fruits are juice, jam, jelly, pickle, wine, etc., which have longer shelf life and higher value than fresh fruits.

1. **Quality planting materials:**

For various fruit crops, improved propagation techniques have been developed to produce quality planting material that is free of diseases. Micro propagation protocols have been established for different fruits, which enable the production of large numbers of disease-free plants. The plant standards for various fruit crops have also been profiled, including traceability.

These techniques and protocols are based on scientific principles and rigorous testing, and aim to enhance the productivity and quality of fruit crops. They also help to conserve the genetic diversity and reduce the risk of spreading pests and diseases. The plant standards provide guidelines for the identification, certification and labeling of the planting material, ensuring its authenticity and traceability throughout the supply chain.

1. **High density planting:**

High density planting (HDP) is one of the important methods to achieve high productivity per unit area with precocity in perennial horticultural crops. Presently, the continued day by day decline in the availability of cultivable land, rising energy and land costs together with the mounting demand for horticultural produce, have given thrust to adoption of HDP in horticultural crops. Furthermore, it is of main concern to the farmers with small landholdings. High density planting is more efficient since it is precocious, easily manageable, has higher yield potential with better quality fruits and higher returns/unit area. HDP, being an intensive system, it requires more capital to establish and is more productive and profitable, if followed scientifically. High density planting is referred as Semi-intensive system accommodating 500-1,000 trees/ha, Intensive system accommodating 1,000 to 10,000 trees/ha employing specialized training systems and Super-intensive system also referred to as ultra high density accommodating 20,000 to 1,00,000 trees/ha.

Promotion of high-density plantings to produce early and sustained production of quality fruits. Area to be expanded in crops like banana, pineapple, grape, guava, mango, litchi, apple, peach, pear and cashew nut *etc*. to refine successful high density planting systems in different tropical, sub-tropical and temperate fruits. There is a need to develop crop-specific strategies for developing high-density plantings. Dwarf and compact trees in high-density orchards should be adopted commercially in temperate horticulture particularly in apple, pear and peach. Adequate emphasis should be laid on the development and evaluation of dwarfing rootstocks apart from mango and citrus where few rootstocks have been identified. High-density plantings require standardization of training and pruning techniques in tropical, sub-tropical and temperate fruits. The success achieved in guava and mango need to promoted to different regions. Alternative to growth retardants like paclobutrazol need to be developed to avoid residual effects. The use of chemicals also needs to be standardized for different fruit crops.HDP should be promoted along with micro irrigation and fertigation methods need to best standardized for different crops and agro-climatic conditions. The mono-species HDP is cost and technology-intensive, suited for commercial fruit production. For small and marginal farmers with smallholdings multi-species HDP approach should be brought out. This system is effective in plantation crops and multiple cropping systems like coconut and arecanut with pepper; tree spices, tuber crops, banana and pineapple are popular in south India. Similarly, the crops where heavy pruning is required such a practice will be highly remunerative.

1. **Protected cultivation:**

Protected cultivation is a technique that allows fruit crops to grow in controlled environments, such as greenhouses, tunnels, or net houses. This method can improve the quality and yield of fruits, as well as reduce the risks of pests, diseases, and adverse weather conditions. Protected cultivation can also extend the growing season and enable the production of off-season fruits. Some of the fruit crops that can benefit from protected cultivation are strawberries, raspberries, blueberries, grapes, melons, and kiwis.

1. **Rejuvenation of old and unproductive orchards**

The technology for rejuvenation of old and unproductive orchards of mango, guava, aonla and cashew nut has been developed. Technology for rejuvenation of old and unproductive mango orchards has been optimized at CISH, Lucknow. Heading back is done on selected unproductive trees during December to encourage new growth during April at lower heights. By proper cultural management (thinning of excessive sprouts, nutrition and water management and pest management) such trees develop new canopy and start fruiting from third year of heading back. Farmers get additional income by sale of pruned wood and intercropping in such orchards. After rejuvenation, fruit yield is enhanced by about 4 times than earlier yields. This technology is being adopted under National Horticulture Mission

1. **Micro irrigation system:**

Drip irrigation is a highly efficient irrigation method well suited to many horticultural crops. Drip tubing or tape discharges water to the soil through emitters positioned close to the plant. The drip tubing can be placed uncovered on the soil surface, under plastic mulch, buried in the soil, or suspended above the ground (e.g., on a trellis system). Water application rate is relatively low and irrigations are usually frequent. Properly designed and maintained drip-irrigation systems can have benefits that increase the profitability of fruit crop production and farmers income.

Precise fertilizer application is possible through the drip irrigation system due to high irrigation application uniformity and irrigation efficiency. Additionally, soluble nutrient losses are reduced due to decreased deep percolation and surface runoff. This reduces fertilizer costs and improves crop yields.

1. **Nutrient management:**

The use of bio-fertilizers and organic matter along with inorganic fertilizers is gaining popularity as a way to cope with the high cost and low availability of fertilizers, and to improve soil health and fertility. Integrated Nutrient Management (INM) is a system that helps to restore and sustain crop productivity, and also assists in checking the emerging micro-nutrient deficiencies in the soil.

Further, it brings economy and efficiency in the use of fertilizers. Integrated plant nutrient management can also be referred to as maintenance of soil fertility and plant nutrient supply to optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner.

1. **Pest management:**

Insect pests can have a negative impact on the quality production of fruits, which is essential for meeting the domestic demands and export potentials. Therefore, it is imperative to adopt effective pest management strategies to ensure the optimal yield and quality of fruits. Farmers are largely not able to ascertain the damage caused by insects and do not aware about the technology to manage them. They are compelled to influence by pesticides firms and dealers which may lead to pause many social and environmental consequences. In this contest, farmers need to be advocated properly for effective implementation of IPM technologies generated by researchers. Truly speaking, IPM does not mean only Integrated Pest Management but it can be also understood as Integrated People Management. A central shift in pest management philosophy to Integrated Pest Management (IPM) can offer immense potential benefits, as it focuses on controlling the pest rather than eradicating it. However, IPM requires a clear understanding and a collaborative approach among the extension workers and the farmers, who should act as consultants and facilitators in disseminating the knowledge and participating actively in the process. While individual adoption of IPM can bring benefits at the farm level, its adoption at the area-wide (AW-IPM) or village level can enhance the sustainability of the technology. However, many socio-economic factors can discourage collective action and increase free riders. Therefore, to reap all possible benefits of IPM technology, IPM also needs to stand for Integrated People Management.

1. **Post harvest management:**

Post harvest management of fruit production is a process that aims to minimize the losses that occur after the fruits are harvested. It involves harvesting the fruits at the right stage of maturity and quality, handling them carefully to prevent mechanical damage, cooling them rapidly to remove field heat, storing them in a modified atmosphere - if suitable technologies are available for the harvested species - and maintaining appropriate temperatures during storage. Post harvest management of fruit production is essential for preserving the quality and shelf life of fruits and reducing food waste. Post-harvest handling activities are crucial for preserving the quality of horticultural crops as they move along the supply chain. Different types of fruits require different packing and storage conditions, depending on factors such as their variety, post-harvest processing, maturity level, and harvest season. For example, apples and pears are best stored at low temperatures and high humidity, while bananas and pineapples need to be ripened at room temperature and low humidity. The factors that affect the optimal conditions for fruits are related to their physiology, biochemistry, and susceptibility to diseases and pests. One way to improve the fruit sector is to use both traditional and modern processing technologies before and after harvesting. This can help reduce the length of the distribution chain and increase the profits. Vertical diversification is the term for this strategy. Therefore, it is essential to adopt appropriate post-harvest practices that suit the specific needs and conditions of each crop and situation.

1. **Biotechnological approach:**

Plant biotechnology has the potential to play a key role in the sustainable production of fruit crops. However, there is enormous potential for genetic manipulation of some vegetative propagated fruit crops in order to improve their disease and pest resistance. The use of appropriate constructs may allow the production of nematode, fungal, bacterial and virus resistant plants in a significantly shorter period of time than using conventional breeding, especially if several traits can be introduced simultaneously. It may also be possible to incorporate other characteristics such as drought tolerance, thereby extending the geographic spread of some fruit crops for production, and thus contributing substantially to enhanced food security and poverty alleviation. However, high caution is required for biosafety experiments and potential risk assessment bearing in mind that these are consumed by most humans and mainly by children.

1. **Export promotional research:**

One of the key requirements for enhancing the export potential of tropical fruits is the development of a bulk handling system that covers pre-cooling, CA/MA storage and post-harvest protocols for sea transport. These measures are essential for major fruits such as banana, mango, litchi, sapota, kinnow and pomegranate, which have high demand in international markets. Another important aspect is the disinfestation technology, such as vapour heat treatment (VHT), which can ensure the phytosanitary standards of fresh fruits and extend their shelf life by preventing desiccation. These technologies can help in promoting the export of tropical fruits and increasing their competitiveness.

1. **Accessing markets and policies:**

Fruit farmers have the potential to increase their income and livelihood by accessing markets and policies that can offer them better opportunities and resources for their fruits. To access domestic markets, they can adopt strategies such as direct marketing to consumers or using online platforms that can reduce intermediaries and increase their profit margins. To access export markets, they need to comply with the quality standards and certifications demanded by the importing countries and seek assistance from agencies that can facilitate their exports. Moreover, they can avail of the policies and schemes of the government such as MIDH, NFSM, PM-KISAN, etc., that can provide them with various forms of financial and technical support such as subsidies, grants, loans, insurance, etc.

**Challenges for enhancing Farmers Income**

Horticulture is an essential part of modern agriculture, providing food, income, and environmental benefits to many communities. However, horticulture faces several major challenges that affect its productivity and sustainability. These include climate change, pests and diseases, water scarcity, labor shortages, market volatility, and consumer preferences. To address these challenges, horticulture needs to adopt innovative solutions and technologies that can enhance its resilience and competitiveness. Research and development play a key role in generating and disseminating such solutions, but it also needs to align with the changing needs and priorities of horticultural producers and consumers. Many of these challenges are quite recent and are of considerable magnitude.

* Economic considerations
* Competitive pricing
* More accurate yield models
* Banking Facilities
* Extending precision farming database to smaller farm size to bigger farm size
* A need for year-round supply to allow consumers continuity of access to specific items of produce
* Growth in supermarkets and corporate farming, poor marketing infrastructure
* Inadequate post-harvest infrastructure and processing facilities
* Complexity in the incidence of pests and diseases
* Identifying ways and means of reducing the cost of RS, GIS technologies and collection, interpretation and dissemination of data to enable their usage on a large scale.
* Availability of trained experts/ human resources