High-tech farming techniques in fruit crops to secure food demand: a review

Abstract

After China, India is the second-largest fruit producer in the world. India produces a wide range of fruits, the most common of which are mango, banana, citrus, guava, grape, pineapple, and apple. In addition to these, a sizable area is dedicated to the cultivation of fruits such peach, pear, almond, walnut, apricot, and strawberry in the temperate group and papaya, sapota, sapota, annona, phalsa, jackfruit, ber, and pomegranate in the tropical and sub-tropical groups. Despite having the second-largest fruit production in the world, the supply of fruits still falls far short of dietary needs. The demand for horticulture produce is on the rise and is predicted to continue to rise as per capita income rises and the population becomes more health conscious, which will lead to a need for more production. However, the production must be affordable while maintaining a high level of quality. The available potential must therefore be utilised in order to sustain progress. The technologies must increase agricultural output, quality, and yield variability while decreasing post-harvest crop losses. Additionally, actions will be required to guarantee the prompt supply of high-quality seed and planting supplies. So, it is anticipated that technology-driven horticulture would solve issues related to complementary and nutritional security, health care, and ultimately economic development.

KEYWORDS: productivity, climate resilient, sustainable, technology-driven, nutrition security

INTRODUCTION

Horticultural crops have significant potential for increasing farm profitability and offering livelihood options in addition to improving biological productivity and nutritional standards. Any such agro-economic strategy would be centred on this category of crops, which includes fruits, vegetables, root and tuber crops, plantation crops, medicinal and aromatic plants, spices and condiments, and ornamental crops. Investments made in the past have paid off in terms of higher production, productivity, and export of horticulture goods. However, there are still a lot of obstacles to overcome. Despite having the second-largest fruit production in the world, the amount of fruits and vegetables available still falls well short of what is needed for a healthy diet. The demand for horticulture produce is on the rise and is predicted to continue to rise as per capita income rises and the population becomes more health conscious, which will lead to a need for more production. However, the production must be affordable while maintaining a high level of quality. The available potential must therefore be utilised in order to sustain progress. Additionally, actions will be required to guarantee the prompt supply of high-quality seed and planting supplies. As a result, horticulture growth must be viewed as an integrated strategy that fills up significant gaps and maximises potential through focused research. So, it is anticipated that technology-driven horticulture would solve issues related to complementary and nutritional security, health care, and ultimately economic development.

Many states, including Maharashtra, Karnataka, Andhra Pradesh, and Kerala, have benefited from the adoption of horticulture (Singh, 2014). According to the rapidly growing population, there is a significant strain on natural resources due to climate change and global warming, shrinking land holdings, and a strong demand for fresh, high-quality horticulture produce. A change to modern crop production methods is necessary, and hi-tech horticulture has already assumed the lead in this regard. The majority of vegetables and other horticultural goods are now available to consumers throughout the year, albeit at a higher cost, thanks to high-tech horticulture's success in overcoming the limitations of agro-climates. Use of genetically modified (GM) crop varieties derived from biotechnology and genetic engineering, micro-propagation, integrated nutrient, water, weed, and pest management, protected cultivation, organic farming, use of contemporary immuno-diagnostic techniques for rapid detection of viral diseases, and post-harvest technologies, including cold chain, are all included in hi-tech horticulture (Chadha, 2001).

WHAT IS HI-TECH FARMING?

- Hi-tech farming is the use of any technology that is cutting-edge, less capital-intensive, less dependent on the environment, and capable of increasing crop productivity and quality (Chadha, 2001).

- It also refers to the exact production methods that maximise yield and quality in various crops by making optimal use of inputs at the proper time and quantity.

- It has also been described as a cutting-edge, acceptable, intense technology that enables farmers to produce goods of high quality and productivity that may fetch higher prices.

NEEDFOR HI-TECH FARMING

The world's population is growing, and traditional farming methods might not be sufficient to meet the increasing demand for food.Moreover**,** the output potential of traditionally cultivated fruit crops in India is far lower than the potential that can be increased by hi-tech methods. By combining innovation, technology, and sustainable practices, hi-tech farming can play a pivotal role in overcoming the challenges of modern agriculture and ensuring a reliable and sustainable supply of fruit crops to meet the needs of a growing global population.The introduction of high-tech farming is essential to addressing the lack of fruits needed to meet suggested dietary requirements. Besides, hi-tech farming can significantly boost production to ensure food security for a growing population.With the world facing challenges such as water scarcity and limited arable land, additionally hi-tech farming methods like drip irrigation, remote sensing, and soil moisture monitoring help conserve resources by delivering water and nutrients precisely where and when they are needed.

BENEFITS

Hi-tech farming techniques in fruit crops can play a crucial role in meeting food security needs. These techniques leverage advanced technologies to increase yield, reduce resource usage, improve crop quality, and enhance overall efficiency in fruit production. Here are some needs and benefits of employing hi-tech farming techniques in fruit crops for food security:

1. **Yield Enhancement**: Hi-tech techniques such as precision agriculture, controlled environment agriculture (CEA), and vertical farming can help maximize yields by optimizing factors like light, water, nutrients, and temperature.

2. **Resource Efficiency**: Limited land and water resources necessitate the efficient use of inputs. Technologies like drip irrigation, soil moisture sensors, and automated nutrient delivery systems help conserve water and nutrients while reducing waste.

3. **Climate Resilience**: Climate change can disrupt traditional farming practices. Hi-tech methods enable growers to create controlled environments that are less affected by external conditions, ensuring stable production even in adverse weather conditions.

4. **Quality Improvement**: Advanced techniques allow for better control over growing conditions, resulting in higher-quality fruits with consistent taste, texture, and appearance, meeting consumer preferences and reducing post-harvest losses.

5. **Reduced Pesticide Use**: Integrated Pest Management (IPM) techniques, which incorporate data from sensors and drones to monitor and target pests, can help minimize pesticide usage while protecting crops from damage.

6. **Data-Driven Decision-Making**: Hi-tech farming relies on data collection and analysis to make informed decisions. This leads to optimized planting times, nutrient application, and harvesting, contributing to higher yields and reduced waste.

7. **Labour Efficiency**: Automation and robotics can reduce the need for manual labour in tasks like planting, harvesting, and maintenance, addressing labour shortages and lowering production costs.

8. **Year-Round Production**: Controlled environment techniques enable year-round cultivation, reducing seasonal variations in supply and ensuring a steady flow of produce to the market.

9. **Varietal Improvement**: Hi-tech methods can aid in developing and selecting fruit varieties that are better suited to changing environmental conditions, pests, and diseases.

10. **Reduced Food Loss and Waste**: Improved monitoring and early detection of issues can help prevent crop losses due to diseases, pests, or unfavourable weather conditions, contributing to food security.

11. **Sustainable Practices**: Many hi-tech farming techniques emphasize sustainability by reducing chemical inputs, conserving water, and minimizing the ecological footprint of agriculture.

IMPACTS OF HI-TECH FARMING TECHNIQUES IN FRUIT CROP PRODUCTION

High density planting, integrated nutrient management based on soil and leaf analysis, micro-irrigation, fertigation, adequate integrated pest, disease, and weed control, appropriate mechanisation, and crucial advances like pre-harvest bagging use are all included in these systems. The situation of fruit crops including bananas, pineapples (*Ananas comosus*), and grapes (*Vitis vinifera*) in India has changed as a result of high-tech technologies.The different types of Hi-Tech farming techniques adoptedin fruit crops are as follows

Fig. 1 High density planting

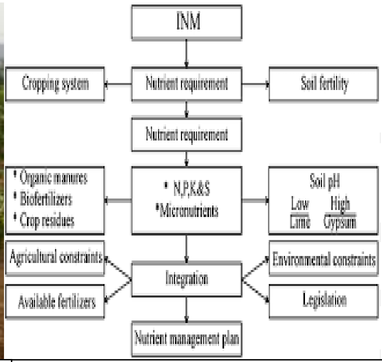

Fig. 2 INM

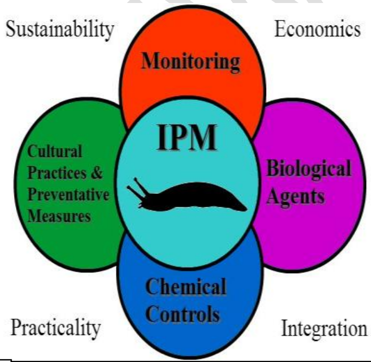

Fig.3 IPM

Fig. 4Fertigation

.Fig. 5 Micro-irrigation

Fig. 6 Greenhouse

Fig. 7 Precision farming

Fig. 8 Post harvest management

High density planting

One key strategy for increasing yield per unit area in both perennial and short-lived horticultural crops is high density planting (HDP). As a result of its early maturity, manageability, larger production potential, better fruit quality, and higher returns per unit area, high density planting is more effective. Planting with a high density can produce a high yield quickly. HDP technology was successfully examined for pineapple, strawberry, papaya, mango, guava, and citrus at the conclusion of the tenth five-year plan (Planning Commission, 2007). Aonla and sapota may also be added to this list (Chadha *et al.,* 2017). When cultivating a range of horticulture crops, high density planting can increase yields and lower costs. High density culture, which allows for a greater yield in less time than traditional cultivation, is becoming more and more common in the fruit industry.Dwarf scion varieties, dwarfing rootstocks and inter-stocks, training and pruning, chemical use, and appropriate crop management techniques are the other four key elements of high density planting. HDP makes use of these elements, which aids in goal achievement. Apple, peach, plum, sweet cherry, and pear are examples of temperate fruit crops that have been successful in their HDP, while banana, pineapple, and papaya are examples of tropical fruit crops. For a number of horticultural crops, high density planting offers the potential to boost yields and lower production costs. According to Dalvi *et al*. (2010), it has already been successfully used in the production of kinnow, oranges (*Citrus sinensis*), pineapples, bananas, and, to a lesser extent, apples (*Malus pumila*) and mangoes (*Mangifera indica*). This goal can be accomplished in a number of methods, including choosing dwarf cultivars and scions, using dwarfing rootstocks and interstocks, pruning, and using growth regulators to maintain the canopy (Haldankar*et al*., 2013).

Choudhary *et al*. (2020) reported thatmango was grown under HDP with Amrapali measuring 2.5 x 2.5 m in a triangle system accommodating 1600 plants and Dashehari measuring 2.5 m x 3 m (1,333 plants per hectare) with pruning and dehorning applied following paclobutrazol application. Each year, yield was guaranteed. In order to allow 3000 and 1088 plants per hectare, respectively, Kinnow on Troyer Citrange and Karna khatta rootstocks could be planted at 1.8 x 1.8 m and 3 x 3 m. With an upgraded package of agro methods at a population density of 63, 758 people per ha, pineapple production increased from 15-20 to 70-80 t/ha. Plants of Pusa Nanha papaya can be spaced 1.25 x 1.25 m apart (6,400 plants per ha).Numerous researchers in the fields of citrus, litchi, banana, and pineapple have reported making comparable observations (Mishra and Goswami, 2016). The guava ultra high density orchard system supports 5000 plants per ha at a spacing of 2.0 x 1.0 m, and is maintained with regular topping and hedging throughout the early phases, which helped in managing tree size and obtaining a greater yield (Singh, *et al.*, 2007). High density plantings of guava, litchi, mango, and papaya have all been successfully proven in India (Lal *et al*., 2007;Mishra *et al*., 2014; Ram,1996).

In another investigation in mango cv. Dashehari, Yogesh *et al*. (2016) discovered that under normal planting density, fruit output was reported to be 22.30 q/ha, however under high planting density, it was 242.20 q/ha at the fifth year of planting. Under the regular way of planting, the fruit output varied from 22.30 to 109.80 q/ha from the fifth to the eleventh year, whereas under the HDP system, it varied from 242.2 to 1093.22 q/ha. From the fifth to the eleventh year of life, the fruit yield ratios for the normal system of planting and HDP were 1:10.86, 1:9.92, 1:9.90, 1:8.67, 1:9.80, 1:9.27, and 1:9.95, respectively. When compared to the standard planting method (1010 m), the fruit production and fruit yield ratio under the HDP system (33 m) were nearly ten times higher. In the Guava cv. Allahabad Safeda, Surendra *et al*. (2013) found that the closest spacing (1x1m) had a fruit production that was considerably higher (114.0 q/ha) than the other spacings. Maximum fruit output was seen for guava trees cultivated in ultra-high density planting when the plants were spaced at 1x1m as opposed to 2x1.5m and 2x1m.

Integrated nutrient management

In order to preserve the desired crop output, integrated nutrient management (INM) refers to the maintenance of soil fertility and plant nutrient delivery to an optimal level. This is done by maximising the advantages of all potential sources of plant nutrients in an integrated way. It is a comprehensive approach in which we first understand exactly what plants need to produce at their highest levels, in what different forms at what different timings in the best method, and how best these forms can be integrated to achieve the highest productivity levels with efficiency at commercially viable limits in an environmentally friendly way. Standardised fertiliser schedules for a variety of perennial crops cultivated in various agro-climatic zones. For monitoring nutrient status and planning fertiliser application, leaf sample methods and critical limits have been established in a variety of fruit and plantation crops, including mango, banana, citrus, guava, pomegranate, ber, and sapota. Fruit crops like mango, banana, citrus, coconut, areca nut, cashew, guava, pomegranate, sapota, apple, etc. are standardised with region-specific INM technology. In order to achieve low pesticide residues and high yields of high-quality crops, INM relies on both mineral and organic sources of nutrients (Domingues *et al*., 2018). It also makes judicious use of pesticides depending on the pre-harvest interval treatment schedule. In other words, it combines the fundamentals of organic management (use of organic materials and sustainability of the entire cultivation system, known as the agroecosystem, promoting food safety) with the structural components of conventional agriculture (proper use of pesticides, sustainable fertiliser management, and minimum tillage) (Asami *et al*., 2003).

According to research by Italiya*et al.* (2016), INM control had considerably more fruits per plant, an average fruit weight of 1.080 kg, a higher fruit production per plant, and an overall fruit output of 80.07 t/ha than the average for organic treatments. The combination of inorganic, organic, and biological sources used in the INM system could be the cause of the increase in papaya growth and yield parameters that were found when INM control was used instead of organic treatments. In compares to using only inorganic sources, the combined application of these sources results in improved soil physical, chemical, and biological qualities.In other experiment, Nurbhane*et al*. (2016) found that the application of 75% RDF (250 g N + 250 g P_2O_5 and 500 g K_2O/plant/year) + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree in treatment T_7 significantly increased fruit yield per tree (46.92 kg) as well as quality-attributing characteristics like minimum acidity (7.32%). In a field study, Srivastava *et al*. (2014) determined that T_{10} (FYM + 100% NPK + Aztobacter + PSB), which was comparable to T_{11} (FYM + 100% NPK + Azospirillum + PSB) and significantly better than the control for papaya cv. Co-7 cultivation on a commercial scale in eastern Uttar Pradesh, India, produced the highest plant growth, yield, and fruit quality. Singh *et al*. (2017) studied the effect of integrated nutrient management on mango cv. Amrapali under high density planting and reported that maximum plant height, spread and number of panicles/plant were recorded in the plants treated with 75% RDF (750:375:750 g of $N:P_2O_5:K_2O$) + 40 kg vermicompost + 250 g Azotobacter + 250 g PSB/plant closely followed by 75% RDF + 20 kg vermicompost + 250 g Azotobacter + 250 g PSB/plant. Whereas, they obtained the highest fruit length, fruit width, fruit weight, fruit yield, TSS, reducing sugar, non- reducing, total sugar and lowest acidity in 75% RDF (750:375:750 g of $N:P_2O_5:K_2O$) + 20 kg vermicompost + 250 g Azotobacter + 250 g PSB per plant treatment closely followed by 75% RDF + 40 kg vermicompost + 250 g Azotobacter + 250 g PSB per plant.Maximum TSS (24.01 ^{o}Brix), reducing sugar (18.92%), non-reducing sugar (3.51%), and total sugar (22.43%) were found by Sangeeta *et al*. (2017) when FYM (at 10 kg per tree), neem cake (at 1.25 kg per tree), vermicompost (at 5 kg per tree), and wood ash (at 3.75 kg per tree) were applied to a banana crop. Suhasini *et al*. (2018) investigated the impact of integrated nutrient management on the growth characteristics of the banana cv. Rajapuri and found that the application of RDF 100% (200,100,300 g NPK) + 20 kg FYM + PSB (20 g) + Azospirilum (20 g) per plant resulted in the highest plant height (197.44 cm) and pseudostem girth (73.05 cm) at shooting. According to Prabhu et al. (2018), the application of the full recommended dose of fertilisers (600:200:300 g NPK per plant/year) plus azospirillum, phosphobacteria, arbuscular mycorrizhal fungi, trichodermaharzianum, and phosphobacteria showed superior performance in terms of yield, yield-attributing factors, and acid lime quality attributes. According to Dwivedi and Agnihotri (2018), applying 50% RDF (250:100:250 g NPK) + 25% FYM + 5% vermicompost to each tree resulted in the highest plant height (3.93 m) and canopy height (3.06 m), spread E-W and N-S (3.85 & 3.66 m), plant girth (0.33 m), leaf length (6.99 cm) and width (3.51 cm) and tree volume (369 m3) as well as significantly increased yield attributes viz., number of fruits per tree (200), weight (258 g) and yield per tree (34.3 kg). Ascorbic acid (206.07 mg/100 g pulp), pectin (0.75%), total sugars (8.21%), reducing sugars (4.15%) and non-reducing sugars (4.06%), as well as minimum acidity (0.23%), were all recorded with the application of 100% NPK + 5 kg vermicompost + 150 gm Azatobactor. The highest yield per tree (60.20 kg), fruit weight (209.88 g), and number of fruits per tree (286.91) were all achieved with the application of 100% NPK + 5 kg vermicompost + 150 g VAM. Tiwari *et al.* (2018) recorded the maximum plant height of 4.07 m, the circumference of the root stock and scion at 38.51 m and 36.57 m, the plant's spread east-west and north-south at 3.79 m and 3.80 m, the leaf length and width at 17.98 cm and 8.94 cm, the tree volume at 184 m3, and the fruit production at 65.58 kg/tree and 181.64 q/ha) in the trees treated with 100% NPK (500:250:500 g) + Zn (0.5%), B (0.2%), Mn (1%) as foliar spray twice + organic mulch (10 cm thick). Tandel *et al.* (2017) indicated that the application of 25% RDN through biocompost + 25% RDN through castor cake + 50% RDN through inorganic fertiliser gave higher values of yield characters viz., number of fruit (28.57), average weight of fruit (1.062 kg), yield per plant (30.24 kg), yield per hectare (83.99 t), fruit diameter (24.87 cm) and fruit volume (900.23 ml) with minimum fruit cavity index (24.13%) and initiation of flowering (105.17 day). Similar results were reported for fruit hardness (7.38 Kg/cm2), shelf life (7.54 days), total soluble solids (8.12%), total sugar

(9.80%), reducing sugar (8.45%), and vitamin C (23.90 mg/100g pulp), along with the least physiological weight loss (11.20%) and titrable acidity (0.016%).

Integrated Pest Management (IPM)

IPM is a complex system approach that comprises of judicious use of cultural, physical, mechanical, biological, host plant resistance, regulatory and chemical methods.It is the methodical evaluation of all available pest control strategies and the subsequent incorporation of suitable controls that thwart the growth of pest populations. In order to cultivate healthy crops with the least amount of pesticide application and to reduce the risks that pesticides cause to human health and the environment, it integrates biological, chemical, physical, and crop-specific (cultural) management techniques and practises. This results in sustainable pest control.Pests of many kinds adversely affect horticultural crops. Over 36% of annual losses are attributable to these pests. Integrated management of these pests is crucial for the success of high-tech horticulture. New pests like thrips, white flies, mites, phytoplasma, viruses, and viroids are appearing as a result of altering horticulture practises. Exotic pests make up some of them. In order to reduce losses brought on by pests like insects, fungi, and bacteria, biological control of pests will be the preferred and ideal strategy as people become more aware of the negative impacts of environmental contamination. Transgenic crops will be the major weapon in this country's fight against the pest threat, coupled with biological control methods. The need-based application of pesticides will need to continue as part of IPM due to the scale of the insect problem. Currently, pesticides are used indiscriminately, which contaminates soil and water and leaves unfavourable residual levels in products.Different meteorological factors affect insect pests and diseases differently depending on the area and crop. Temperatures of at least 35°C during the day and 23°C at night, along with humidity levels of 50–80% and vapour pressure readings of 20–24 mm Hg, were found to be favourable for mango hopper breeding and to aid in boosting population growth in the following months (Pandey *et al*., 2003).In 1990, Hansen and Amstrong noted that mango stone weevil infection in Hawaii was unaffected by orchard cleaning. Fruit trees that have been neglected or untreated are the main breeding grounds for fruit flies. Cultural practises normally do not directly aid the reduction of pests. According to Hoyt and Burts (1974), when utilised correctly, they can increase the activity of natural enemies to a certain extent, which is crucial in integrated pest control programmes. It is also a good cultural practise to remove related host plants for polypahgous pests to lower pest incidence.

According to Gold *et al*. (2003), paring suckers will destroy the majority of weevil eggs and many first-instar larvae. However, paring will not get rid of larvae that are deeply embedded in the corm. Parted suckers should be submerged in hot water baths (e.g., 52–55°C for 20–27 min.) to kill the larvae and reduce the prevalence of nematodes. However, in Uganda, just 32% of the weevil larvae in the corm were destroyed by hot water baths. During the plant crop but not the first ratoon of a field trial, weevil damage was less severe on plots planted from pared and hot-water treated suckers than on controls.Therefore, it is unlikely that the use of clean planting material will result in the long-term control of banana weevils.In a one-year on-farm study in Uganda, Gold *et al*. (2002) found that weevil populations decreased by 61% on farms that had monthly trapping (one pseudostem trap per mat), compared to a 38% decline on farms that had none. However, results varied significantly among farms, and overall, trapping had no statistically significant impact on weevil populations.Gold *et al*. (2003) have reviewed the use of arthropod natural enemies against banana weevil. The most significant generalist predator discovered during the first half of the 20th century's hunt for natural enemies in South-East Asia was *Plaesiusjavanus* Erichson (Coleoptera, Histeridae). P. *javanus* and seven additional predators were used in traditional biological control strategies, but they were unsuccessful. Recently, no parasitoids were discovered in 19,000 eggs and 1500 larvae that were raised in the lab after being collected from Indonesian banana stands.Godonou*et al*. (2000) carried out field trials in Ghana to assess the field effectiveness of B. bassiana conidia on OPKC applied to planting holes and pure conidial powder applied to plantain suckers right before planting. Then weevils with markings were introduced into each plot. After 28 days, suckers treated with OPKC yielded 31% of the designated weevils, of which 24% were infected. While controls exhibited a 50% recovery rate and no infection, suckers treated with conidial powder showed a 23% recovery and 30% infection rate. Compared to 1% for controls, Godonou*et al*. (2000) calculated 76% mortality in the two B. bassiana treatments.In a different field experiment, Nankinga (1999) sprayed topsoil around banana mats in small plots (i.e., eight mats) covered with grass and banana trash mulch with 500 g of a maize-based formulation of B. bassiana (10 15 conidia ha - 1), 500 g of a soil-based formulation (10 14 conidia ha - 1) or 30 ml of an oil formulation (10 15 conidia ha - 1. Weevils were trapped every week for eight months. The plots treated with the maize formulation had the lowest mean weevil counts, followed by the plots treated with the soil formulation, oil formulation, and controls.

Fertigation

Fertigation, in which fertilisers and water are fed to growing crops through a micro irrigation system, is the greatest option for more productive, intense crop production. Fertigation delivers nitrogen, phosphorus, potassium, as well as vital trace elements (Mg, Fe, Zn, Cu, MO, Mn) straight to the active root zone, minimising costly nutrient losses in the process. This helps to increase farm output productivity and quality. Fertigation is perfectly suited for high-tech horticultural production systems since it not only assures the simultaneous availability of the two most valuable inputs, water and nutrients, to plants, but also ensures their optimal use. Through high-tech productivity employing fertigation, significant yield response as well as improved produce quality is feasible. Banana, grape, papaya, pomegranate, and mandarin fertilisation is standardised to boost output and fruit quality while reducing water and fertiliser use by 30 to 40%. Most horticultural crops now have higher yields and greater quality thanks to the adoption of fertigation. Technology aids in productivity gains of 30% to 100%. Improved water usage efficiency (WUE) is present.Due to their perpetual nature and the fact that they serve as significant sinks for absorbed nutrients, fruit crops are very nutrient demanding (Srivastava and Shirgure, 2017).

According to research by Sudharshan *et al.* (2017), treatment T2 with 115% NPK fertigation produced the largest incremental plant height (0.63 m) and stem girth (5.83 cm) in Nagpur mandarin. However, 100% fertigation with RDF produced the largest number of fruits per plant (649.86), fruit yield (107.98 kg/plant), and yield per hectare (29.9 t/ha), which was comparable to fertigation with 115% and 85% of the necessary dose of fertilisers. Juice content (52.32%) and TSS (11.06 0Brix) measurements of superior fruit quality were seen in 85% of the fertigation using RDF. Fertilisers applied to the soil and fertigation at doses of 70% and 55% of the recommended NPK fertiliser dose respectively resulted in lower growth, yields, and quality attributes. In another field study conducted on strawberry, S.K. Dilip and J.S. Chandel (2015) demonstrated that fertigation with the recommended dose of NPK significantly increased plant height (24.23 cm), leaf area (129.20 cm2), and fruit yield (35.64 t/ha) compared to fertigation with the 12 and 1/3 of the recommended dose of NPK and soil fertilisation, but was found to be comparable to fertigation with the 34 recommended dose of NPK. In fertigation with the full advised dose of NPK, the highest fruit weight (19.87 g) was also noted. In comparison to lower levels of fertigation and soil fertilisation, the values of TSS (9.880B) and total sugar (9.44%) were significantly greater in fertigation with the recommended dose of NPK treatment.According to Singh *et al*. (2017), apple fertigation yielded the highest outcomes in terms of increased shoot development, bud formation, fruit sets, and cumulative yield. Fertilisation generated increased branch growth combined with an excess of axillary flower buds that scattered, leaving bare, unproductive wood. In a research investigation, the effects of NPK administration via the fertigation procedure on the developmental features of apple cv. Red Chief were examined. The full dosage of NPK administered via drip irrigation resulted in the highest vegetative development of plants as measured by shoot length, plant diameter, number of leaves, leaf area, fresh weight, and dry weight of leaves (Corrêa *et al*., 2018).Although the calcium content of apple fruits increased somewhat in the plots fertilised with calcium nitrate, neither firmness nor storage behaviour were affected (Motesharezadeh*et al*., 2021). Greater nitrogen concentrations were frequently seen in leaves and fruits after fertigation, which hindered the development of skin colour. Researchers looked at the effects of different fertigation and soil fertilisation rates on strawberry (*Fragaria ananassa* Duch.) growth, fruit quality, yield, and leaf nutrient content. The results showed that fertigation with the recommended NPK dosage considerably enhanced the plant's height, leaf area, and Fruit yield was found to be comparable to treatments using 3/4 of the recommended NPK fertilisation dose when compared to fertigation with 1/2 and 1/3 of the recommended NPK dose and soil fertilisation. The maximum fruit length, fruit breadth, and fruit weight were also noted in fertigation with the full recommended dose of NPK (Kachwaya*et al*., 2015).

Micro-irrigation

Improved irrigation water use efficiency is required, according to FAO, in order to boost irrigation's impact on food production (FAO, 2003). The fact that water-saving technology, in particular micro-irrigation/drip irrigation, can boost yields and slow salinization is a significant advantage. Furthermore, brackish water can be used with either approach for crops that are not very sensitive to salinity because neither method brings water into touch with the foliage (Cetin, 2004).Micro-irrigation, which is the precise distribution of water on or below the soil surface at low pressure using small devices that spray, mist, sprinkler, or drip water, is becoming more alluring in light of irrigation efficiency and environmental concerns (Hla and Scherer, 2003). Micro-irrigation has been widely adopted in recent decades as a result of rising sales and technological advancements. A typical type of micro-irrigation is drip irrigation. According to irrigation statistics (Maadramootoo and Morrison, 2013), the number of acres irrigated with drip irrigation has increased quickly across various nations.Utilising various components depends on the need, which can change depending on the crop type, water needs, plant spacing, soil type, etc. Drip/Micro irrigation technology can be applied both above and below ground. With sprinkler irrigation, water is sprayed on plant foliage using a network of pipes and sprinklers (nozzles). To prevent irrigation water wastage, several fruit crops, including mango, citrus, sapota, banana, pomegranate, and grape, have micro-irrigation needs and fertigation scheduling created.Drip irrigation is now a widely used irrigation practice worldwide. Compared to traditional watering methods, drip irrigation has many benefits. These benefits include the most effective use of irrigation water, the most efficient use of water by giving water to the roots of the plants, and the least amount of soil moisture loss through evaporation.

According to Dhakar*et al*. (2013), drip irrigation performed better than conventional irrigation when the necessary dosages of fertilisers were administered to pomegranate plants. The investigations on the impact of drip and traditional irrigation technologies on the yields of strawberry, banana, and citrus were carried out in Turkey by Tekinel*et al*. in 1989. The findings demonstrated that drip irrigation produced the highest yields and crop quality.According to a compilation of research findings from multiple Indian research institutes, drip irrigation often results in water use reductions of 30–60% and yield increases of 20–50% for crops like grapes and bananas (Kooij*et al*., 2013). Shah (2011) and other researchers have noted the water savings and production improvements brought on by microirrigation (Table 1).

Table 1. Drip and surface irrigation- water saving and increase in yield (Shah, 2011)

Crop	Yield (kg ha^{-1})			Irrigation		
	Surface	Drip	Increase (%)	Surface	Drip	Saving (%)
Banana	57 500	87 500	52	176	97	45
Grapes	26 400	32 500	23	53	28	47
Pomegranate	3 400	6 700	97	21	16	24

Protected/ greenhouse cultivation

Progressive horticulture growers are increasingly using greenhouse or protected cultivation methods. In comparison to conventional production methods, this high-tech horticulture technology has a number of advantages. For example, horticultural items, including fruits, vegetables, and flowers, can be grown under protected cultivation even during their off-seasons. In this kind of farming, the microclimate is completely or partially managed to safeguard the plant from unfavourable climatic conditions. In addition to increasing production in a small area, this also makes it possible to grow crops under unfavourable conditions and during non-growing seasons. It ensures the year-round availability and productivity of any plant, wherever it may be, a flawless, high-quality product, diseases and insect infestations are fairly manageable, water usage reduces, lower labour requirement, earliness because it shortens the crop season.Such systems have several benefits, including simpler cultivation (irrigation, weed control, pest management, and harvest), a lower yield lost to ecological factors, the ability to work in any weather, an increase in marketable fruits, a consistent high yield, and most importantly, earlier harvesting and higher profitability (Fideghelli, 1990; Furukawa, 1990). India is the second-largest fruit producer in the world, however because of the influence of biotic and abiotic factors, production and quality were lower, which will also limit India's ability to export fruit. Fruit production in greenhouses has the potential to improve fruit crops' output, quality, off-season cultivation, and exportability. In order to compete with fruit imports during the off-harvest season and to improve fruit quality, protected farming was started in Japan (Iwagaki, 1990).

A study was conducted by Mireille *et al*. (2019) to determine how well papaya adapted to protected cropping systems (in a greenhouse). Although there were also other varieties which gave results that made possible its cultivation under this production system, the hermaphrodite Intenzza papaya grafted on female papaya rootstock produced the best yield parameters and fruit qualities.According to Kamiloglu*et al.*(2011), vines cultivated under protection reached bud break 9 days earlier, full bloom 14 days earlier, veraison 16 days earlier, and maturity 17 days earlier than vines produced in open fields. Phenological phases were also seen earlier in protected plants than in plants grown in open fields. The longest cluster length was found in "Uslu" (22.39 cm), and the largest cluster weight and breadth values were found in "Ergin cekirdeksizi" (322.42 g and 10.27 cm, respectively) (Kamiloglu*et al.* 2011). According to Vool*et al.*(2013), the concentration of soluble solids was between 24.1 and 25.4 ^{o}Brix while it was between 17.9 and 21.8 ^{o}Brix under open conditions. The lowest titrable acidity (1.2-1.2 g/100g) was seen in protected cultivation of grape cultivars (HasanskiSladki and Zilga, respectively), and the highest titrable acidity (1.2 g/100) and maximum TA (1.5-1.6 g/100g) noticed in open condition. In bananas, Gubbuk and Pekmezci (2004) discovered that both the bunch stalk circumference and the number of hands varied significantly: the bunch stalk circumference was 22.2 cm in open fields and 25.4

cm in protected cultivation, and the number of hands was 10.6 in open fields and 12.9 in protected cultivation.

Precision farming

Precision farming emphasises the most recent technological advancements and improvements in agricultural production. This indicates that the producer is well aware of the best way to manage his crop production to produce the best yield and quality possible. It not only promotes environmental wellness but also boosts its profitability by combining minimal input with maximum output without wasting energy. Precision farming encompasses all high-tech horticulture equipment like GPS, GIS, DGPS, remote sensing.GPS devices gather position data to map crop problems like weeds and diseases as well as the boundaries of fields, irrigation systems, and highways. Farmers may create farm maps with accurate acreage for field areas, positions on the road and separations between sites of interest thanks to GPS accuracy. These technologies are utilised in crop scouting, yield mapping, soil sampling, and farm preparation. With the help of these cutting-edge technologies, farmers can grow their crops precisely by using the right amounts of pesticides, herbicides, and fertilisers. Drones are the wireless, sensor-equipped equipment used for field surveys. They are able to take high-quality pictures and easily gather the entire data set at lower altitudes. Insecticides and pesticides are also sprayed on fields using these.

According to Theofanis Gemtosa*et al*. (2013)'s analysis, three years' worth of yield, quality, and NDVI maps were produced using precision agriculture in hand-picked apple and grape orchards in Greece. The outcomes for both crops demonstrated that the measured parameters were highly variable. The maps' comparison revealed that fruit quality was lower in locations with large yields. Beginning in June, NDVI maps in apple trees were associated with the final yield variability. This finding can be utilised to manage the anticipated fluctuation and as an early warning of yield variability.For vines, similar outcomes were suggested.In order to determine the grapevine canopy parameters, Tagarakis*et al.* (2013) at various points in the vine growth cycle, they measured NDVI. At harvest, they mapped the grape composition (must sugar content and total acidity). They observed high spatial diversity in the parameters of soil characteristics, yield, and grape content. By transforming all measured data onto a 48-cell grid (10 20 m), they used MZA software to create maps of two management zones. The percentage of pixels that belong to the same zone could be calculated by pixel-by-pixel comparing maps of electrical conductivity, elevation, slope, soil depth, and NDVI with yield and grape composition maps, which were used as reference data.They chose the ideal parameters for the final demarcation of management zones based on the level of agreement. Early and midseason NDVI were used for soil depth in 2009 for yield-based management zones and early and midseason NDVI were used for quality-based management zones (ECa). For the year 2010, yield-based management zones were defined using ECa, elevation, and NDVI data acquired during flowering and veraison, whereas quality-based management zones were defined using ECa and NDVI data acquired during flowering and harvest.

Post-harvest management

Standardisation of chemical pre- and post-harvest procedures to prevent post-harvest illnesses in citrus, mango, and bananas for long-distance shipping and storage. Post-harvest procedures for extending the shelf life of fresh fruits, vegetables, floriculture products, and processed fruits and vegetables include pre-cooling and passive evaporative cooling. Corrugated Fiberboard boxes (CFBs), perforated punnettes, cling film wraps, sachets, poly crates, mess bags, tetrapacks, laminated bags, multi wallpaper, sacks, and flexible packaging substances were all created for the packaging of fresh and processed goods. There are protocols for making jam, jelly, candy, RTS, nectar, squash, and juice available. Other innovative products include essential oils from citrus fruits, fruit wines, and dried items made from grape, pomegranate, mango, and apricot.

In a research on mango, Jakhar and Pathak (2015) came to the conclusion that hot water treatment (HWT) combined with wax coating was the most effective way to reduce the amount of black spots and contaminated fruit during storage. While untreated fruits only lasted six days under ambient storage, treated fruits kept their maximum amount of firmness and highest organoleptic score. The shelf life of mango fruits enhanced with treatments of HWT + Wax coating as well, reaching 15 days with the lowest PLW percentage compared to just 9 days in the control. The most effective method for preventing black spots and other blemishes was post-harvest treatment with HWT at 52 20C for five minutes plus wax coating of 6% wax emulsion (T3) and infestation of fruit fly with prolonged shelf life of mango fruits cv. Amrapali.In an experiment, Naser Alemzade Ansari (2007) found that applying hot water, wax, and TBZ fungicide treatments reduced postharvest deterioration, particularly penicillium moulds. When these treatments were applied to the Siavars cultivar, decay decreased to 2% as opposed to 26.7% under the control treatment. Wax application considerably reduced the decline in fruit tissue hardness, ascorbic acid, and weight. The inhibition of fruit weight and tissue hardness was greatly reduced by hot water treatment, although ascorbic acid content fell. Titratable acidity (TA%) and ascorbic acid concentration both considerably decreased throughout the cold storage period. The content of Total Soluble Solids (TSS) and the ratio of TSS/TA rate, on the other hand, both dramatically rose.

Roseane*et al.* (2011) discovered that the control fruit (lot 1) lost almost twice as much weight as the uncoated chilled fruit (lot 2) and the coated mangoes at both temperatures (lots 3 and 4); the control fruit also softened more quickly. Superoxide dismutase activity decreased throughout storage without statistically differing between treatments for the antioxidant enzymes, whereas catalase activity was significantly reduced when kept in the refrigerator. At ambient temperature, coating delayed the catalasic activity peak to day 12, which was coincided with the lowest lipid peroxidation degree, illustrating the link between free radical production and scavenging mechanisms. The galactomannan coating was successful in minimising weight loss and delaying softening; hence, it preserved quality of 'Tommy Atkins' mangoes for a longer amount of time than the control treatment during storage at ambient temperature.The galactomannan coating performed better under refrigeration (14 °C), which also helped to slow down metabolism and postpone softening until day 12.Raheel Anwar and Aman Ullah Malik (2007) reported that fruit subjected to HWT at 45°C for 75 minutes while being naturally ripened (without storage) did not differ significantly from control fruit that had just been washed, retaining the fruit's shelf life of six days. The ripening period, or three days, was shortened by the application of HWT at 48°C for 60 minutes. HWT does not have an impact on the fruit's post-storage quality, as seen by the lack of substantial changes between treatments throughout storage. Fruit submitted to HWT at 45°C for 75 minutes produced better results than fruit subjected to HWT at 48°C for 60 minutes among the other treatments. The highest TC concentration was detected in fruits that had just been washed (62.78 g/g), followed by HWT at 45 °C for 75 minutes (59.3 g/g).

CONSTRAINT IN ADOPTING HI TECH FARMING

The adoption of hi-tech farming techniques in fruit crops can be constrained by several factors, including:

1. **High Initial Investment**: Many hi-tech farming technologies require significant upfront investments in equipment, infrastructure, and technology systems. This can be a major barrier for small-scale or resource-constrained farmers.

2. **Lack of Access to Technology**: In many regions, especially in developing countries, farmers may not have easy access to the latest hi-tech farming tools and technologies, including advanced machinery and sensors.

3. **Technical Knowledge and Training**: Implementing hi-tech farming techniques often requires specialized knowledge and skills. Farmers may lack the training and technical expertise needed to operate and maintain these systems effectively.

4. **Infrastructure and Connectivity**: Access to reliable electricity, internet connectivity, and other essential infrastructure can be a challenge in rural areas. Many hi-tech farming tools rely on these services to function optimally.

5. **Cost of Maintenance and Repairs**: Hi-tech farming equipment and systems can be expensive to maintain and repair. Farmers need access to reliable service providers and spare parts to keep their technology running smoothly.

6. **Data Management and Analysis**: Collecting and analysing data from hi-tech farming systems can be complex. Farmers may need assistance with data management and interpretation to make informed decisions.

7. **Climate and Environmental Factors**: Climate variability and extreme weather conditions can impact the effectiveness of hi-tech farming techniques. For example, sensor-based irrigation systems may not work as expected during droughts or heavy rainfall.

8. **Crop Variability**: Different fruit crops have varying growth patterns, requirements, and sensitivities. Hi-tech solutions may not be universally applicable and may need customization for specific crops.

9. **Regulatory and Policy Barriers**: Government regulations and policies can influence the adoption of hi-tech farming techniques. In some cases, regulations may not support or may even hinder the use of certain technologies.

10. **Market Demand and Price Volatility**: The market for fruit crops can be unpredictable, with fluctuating demand and prices. Farmers may hesitate to invest in hi-tech solutions if they are unsure about the return on investment.

11. **Cultural and Social Factors**: Traditional farming practices and cultural norms can be resistant to change. Farmers may be hesitant to adopt new technologies if they perceive them as a departure from their familiar methods.

12. **Environmental Concerns**: Some hi-tech farming techniques, such as heavy pesticide or fertilizer use, may raise environmental concerns. Farmers may face opposition from environmentalists or consumer groups when adopting certain technologies.

13. **Access to Financing**: Securing financing for hi-tech farming investments can be challenging, especially for small-scale farmers who may have limited access to credit or loans.

14. **Market Access**: Hi-tech farming can increase productivity, but without proper market access, farmers may struggle to sell their produce at competitive prices.

15. **Long-Term Viability**: Farmers may question the long-term viability of hi-tech farming techniques and whether the benefits will outweigh the costs over time.

Addressing these constraints often requires a combination of technical support, training, policy adjustments, and financial incentives to encourage the adoption of hi-tech farming techniques in fruit crops.

CONCLUSION

We can feed the growing population while facing numerous difficulties if we combine current ideas and techniques with traditional agriculture. The world is always creating new approaches. This will not only contribute to the sustainability of the produce but also to the improvement of farmers' financial circumstances.To effectively implement hi-tech farming techniques in fruit crops for food security, there is a need for investments in research and development, training for farmers, access to technology and infrastructure, and supportive policies from governments and agricultural institutions. Collaboration between the agricultural sector, technology providers, researchers, and policymakers is essential to harness the full potential of these techniques and ensure global food security.

REFERENCE

Ansari, N. A. and Feridoon, H. 2007. Postharvest Application of Hot Water, Fungicide and Waxing on the Shelf Life of Valencia and Local Oranges of Siavarz**.** *Asian J. Plt Sci*., 6(2): 314-319.

Anwar, R. and Malik, A.U. 2007. Hot water treatments affect ripening, quality and storage of mango (*Mangifera indica*L). *Pak. J. of Agri. Sci*., 44(21).

Asami, D.K., Hong, Y.J., Barrett, D.M. and Mitchell, A.E. 2003. Comparison of the total phenolic and ascorbic acid content of freeze-driedand air-dried marionberry, strawberry, and corn grown using conventional, organic, and sustainable agricultural practices. *J.Agric. Food Chem*., 51, 1237–1241.

Bhattacharyya, T., Haldankar, P.M., Patil, V. K., Salvi, B. R., Haldavanekar, P.C., Pujari, K. H. and Dosani, A. A. 2017. Hi-tech Horticulture: Pros and Cons. *Indian J. of Fert.*, 13 (12),.46-58.

Butler, G., Nielsen, J.H., Slots, T., Seal, C., Eyre, M.D., Sanderson, R. and Leifert, C. 2008. Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. *J. Sci. Food Agric*., 88: 1431–1441.

Cetin, Ö.,2004. Role of the Micro Irrigation on Sustainability of Soil and Water Resources. Proceedings of the International Soil Congress on Natural Resource Management for Sustainable Development, E 57-65, Erzurum, Turkey.

Chadha, K.L. 2001. Hi-tech Horticulture in India. Policy Paper 13. National Academy of Agricultural Sciences, New Delhi.

Chadha, K. L. and Choudhary, M. L. 2007-2012. Planning Commission. Report of the Working Group on Horticulture, Plantation Crops and Organic Farming for the XI Five Year Plan. Planning Commission, Govt. of India.

Chadha, K.L., Singh, S.K., Kalia, P., Dhillon, W.S., Behera, T.K. and Jai Prakash .2017. Doubling Farmers Income through Horticulture. The Horticulture Society of India and Daya Publishing House, NewDelhi.

Chand, R. 2008. High value agriculture in India. In Souvenir – 3rd Indian Horticulutre Congress. The Horticultural Society of India, New Delhi.

Choudhary, S. M., Sarkar Tanmoy and Magar, V.G. 2020. High Density Planting System in Fruit Crops. *AgriCos e-Newsletter*, 01: 04.

Corrêa, M.C., Natale, W., Prado, R.D., Banzatto, D.A., Queiroz, R.F., Silva, M.A.2018. Surface application of lime on a guava orchard in production. *Revista Brasileira de Ciência do S*olo; 2(42).

Dalvi, N.V., Salvi, B.R., Chavan, S.A. and Kandalkar, M. P. 2010. High density planting in mango cv. Alphanso. *Hort. Sci.*,5(2):117-119.

Dhakar, M.K., Kaushik, R.A.,Sarolia, D.K. and Bana, M.L. 2013. Effect of fertigation through low cost drip irrigation system onvegetative growth characteristics in pomegranate cv. Bhagwa.Green Farming, (1): 33-36.

Dilip, S. K. and Chandel, J. S. 2015. Effect of fertigation on growth, yield, fruit quality and leaf nutrients content of strawberry (Fragaria × ananassa) cv Chandler. *Indian J. of Agril.Sci*.85 (10): 1319–23.

Domingues, A.R., Vidal, T.C.M., Hata, F.T., Ventura, M.U., Gonçalves, L.S.A. and Silva, J.B. 2018. Postharvest quality, antioxidant activityand acceptability of strawberries grown in conventional and organic systems. *Braz. J. Food Technol*., 21.

Dwivedi, V. and Agnihotri, S. 2018. Effect of integrated nutrient management on growth, yield and economics of guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Int. J. Current Microbiol. Applied Sci.*, 7(6):3449-3453.

Eckstiin, K. and Joubfrt. W., Greenhouse cultivation of banana in South Africa. *Acta Horti*., 490**:** 135-145 (1998).

Fideghelli, C., Protected cultivation of tree fruits in Italy. *Chronica Horticulture*, 30(1**):** 5–6 (1990).

Food and Agriculture Organization of the United Nations (FAO), 2003. Water Management towards 2030. www.fao.org/ag/magazine/0303sp1.

Furukawa, Y., Kataoka, T. and Shimomura, M. 1990. Productivity of high density peach orchard using of free rootstock (*Prunus persica* Thunb). In: Proceedings of XXIII International Horticultural Congress, 4169 Frienze, Italy.

Ghosh, S.N., Bera, B., Roy, S. and Kundu, A. 2009. Effect of plant growth regulators in yield and fruit quality in pomegranate cv. Ruby.*J. Hortl. Sci*.,4 (2): 158-160.

Godonou, I., Green , K.R. , Oduro, K.A., Lomer, e.J. and Afreh-Nuamah, K. 2000. Field evaluation of selected formulations of Beauveriabassiana for the management of the banana weevil (*Cosmopolites sordidus*) on plantain (*Musa spp*., MB group). *Biocontrol Sci. Technol*., 10, 779-788.

Gold, e.S., Okech, S.H. and Nokoe, S. 2002. Evaluation of pseudostem trapping as a control of banana weevil, Cosmopolites sordidus (Germar), populations and dam-age in Ntungamo district, Uganda. Bulletin of Entomological Research 92, 35-4.

Gold, C.S., Nankinga, C., Niere, B. and Godonou, I. 2003. IPM of banana weevil in Africa withemphasis on microbial control, pp. 243–257. In: Neuenschwander, P., Borgemeister, C.

andLangewald, J. (eds), *Biological Control in IPM Systems in Africa*. CABI Publishing, Wallingford,400p.

Gubbuk, H. and Pekmezci, M. 2004. Comparison of open-field and protected cultivation of banana *(Musa* spp. AAA) in the coastal area of Turkey. *New Zealand J. Crop Hortl Sci.,* 32**:** 375-378.

Hansen, J.D. and Amstrong, J.W. 1990. The failure of field sanitation to reduce infestation bymango nut weevil, Crytomangiferae in Hawaii. *Trop. Pest Manage.*36: 359–361.

Haldankar, P.M., Parulekar, Y.R., Haldavanekar, P.C., Pawar, C.D., Desai, V.S. and Pandey, V.S. 2013. Mango Production Technology. Dr.Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Hla AK. and Scherer T.F. 2003. Introduction to micro-irrigation. North Dakota State University Extension Service, AE-1243: Fargo, N.D., USA.

Hoyt, S.C. and Burts, E.C. 1974. Integrated control of fruit pests. *Annales Rev. Entomol.*,19:231–252.

Italiya, A.P., Patel, P.S., Patel, T.U., Narendra Singh and Kaswala, A.R. 2017. Growth, yield and economy of papaya as influenced by organic and integratednutrient management farming system under South Gujarat condition.*Res. Environ. Life Sci*., 10(5): 414-417.

Iwagaki, I., Satsuma mandarin cultivation in vinyl greenhouse. 1990. In: Proceedings of the International Citrus Symposium. Guangzhou, China, pp. 439–445.

Jakhar, M. S. and Pathak, S. 2015. Effect of post harvest treatments on black spotting, infestation and organoleptic quality of Amrapali mango during ambient storage. Plant Archives, 15, 109-113.

Kachwaya, D.S. and Chandel, J.S. 2015. Effect of fertigation on growth, yield, fruit quality and leaf nutrients content of strawberry (Fragaria× ananassa) cv Chandler. *Indian J.Agril.Sci*.. 85(10):1319-23.

Kamiloglu, Ö., Atilla Aytekin Polat, and Coşkun Durgaç, 2011. Comparison of open field and protected cultivation of five early table grape cultivars under Mediterranean conditions. *Turk J Agric*., 35**:** 491-499.

Kaswala, A. R., Dubey, P. K. and Patel, K. G. 2017. Organic Farming in Banana Bull. *Env. Pharmacol. Life Sci*., 6(10):111-116.

Kooij, A., Zwarteveen, M., Boesveld, H. and Kuper, M. 2013. The efficiency of drip irrigation unpacked. *Agril. Water Manage*. 123 (2013) 103-110.

Kumah, P., Appiah, F. and Opoku-Debrah, John K.. 2011. Effect of hot water treatment on quality and shelf-life of Keitt mango. *Agric. Biol. J. N. Am*., 2(5): 806-817.

Lal, S., Tiwari, J. P. and Mahajan, A. R. 2007. Studies on planting systems in guava (Psidium guajavaL.) cv. Sardar. *Acta Hort*., 735: 263-266.

Madramootoo, C. A. and Morrison, J. 2013. Advances and challenges with micro-irrigation. Irrigation and Drainage. Published online in Wiley Online Library DOI**:** 10.1002/ird.1704

Mireille, N., Honoré, Luis, J., Belmonte-Ureña, Asensio Navarro-Velasco and Francisco Camacho-Ferre. 2019. The Production and Quality of Di_erent Varieties of Papaya Grown under Greenhouse in Short Cycle in Continental Europe. *Int. J. Environ. Res. Public Health*. 16: 1789.

Mishra, D. S. and Goswami, A. K. 2016. High density planting in fruit crops. *Hort. Flora. Res. Spectrum*, 5(3):261-264.

Motesharezadeh, B, M. Q., Tabibi, A.R., Fatemi, R. and Bekhradi, F. 2021. Nutritional, yield, and quality responses of apple, pear, and cherry to calcium nitrate application. Communications in Soil Science and Plant Analysis, 52(10):1132-48.

Nankinga, C.M. 1999. Characterization of entomopathogenic fungi and evaluation of delivery systems for the biological control of the banana weevil, *Cosmopolites sor-didus*. PhD thesis, University of Reading, Reading, UK.

National Horticulture Board. 2017. Area-production statistics. Ministry of Agriculture. Govt. of India, Available: http://nhb.gov.in/statistics/area-production-statistics.html.

Nurbhane, K.H., Patel, M. J., Barot H.R., Thakkar, R.M. and Gadhavi, A.V. 2016. Effect of integrated nutrient management (INM) on growth, yield and quality of acid lime (*Citrus aurantifolia* swingle) cv. Kagzi. *Inter. J. of Agric. Sci*.51:2360-2363.

Pandey, V., Patel,M.G., Chaudhari, G.B., Patel, J.R., Bhatt, B.K., Vadodaria, R.P. and Shekh, A.M.2003. Influence of weather parameters on the population dynamics of mango hopper. *J. Agrom.*5(1): 51–59.

Planning Commission. 2007. Report of the Working Group on Horticulture,Plantation Crops and Organic Farming for the XI Five Year Plan (2007-2012).Planning Commission, Govt. of India.

Ram, S. 1996. High density orcharding in mango. *Res. Bull.* 122, DES, GBPUAT, Pantnagar. pp. 1-24.

Ram, H., Heman, K. P., Prabakar, S., Tiwari, S. P. and Saxena, R. R. 2017. Effect of plant growth regulators on growth, yield and quality of papaya (*carica papaya* l.) Cv. Red lady under net house. M.Sc. (Hort.) Thesis, Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh).

Reddy, B.M.C. 2004. High density planting in horticultural crops. In Crop Improvement and Production Technology of Horticultural Crops. Volume 1. (K.L. Chadha, B.S. hluwalia, K.V. Prasad and S.K. Singh, Eds.), 295-319. The Horticulture Society of India, New Delhi.

Reddy, Y.T.N., Kurian, R. M.,Ganeshamurthy,A.N., Pannerselvam, P. and Shivu, P.S.R.2013. Influence of organic practices on growth and fruit yield in papaya cv. Surya. *J. Hortl. Sci.*8(2):246-248.

Reganold, J.P., Palmer, A.S., Lockhart, J.C. and Macgregor, A.N. 1993. Soil quality and financial performance on biodynamic and conventional farms in New Zealand. Science, 260: 344-349.

Roseane P. Aguiar, Maria Raquel A. Miranda, Álvaro M. P. Lima, José L. Mosca, Renato A. Moreira, Joaquim Enéas-Filho. 2011.Effect of a galactomannan coating on mango postharvest physicochemical quality parameters and physiology. Fruits, 66(4):269-278.

Sangeeta BH, Shorol AM, Suresh H, Lenkennavar GS, Swamy K. 2017. Effect of organic manures on yield and quality of banana cv. Grand Naine. International Journal of Pure and Applied Bioscience, 5(6):1094-1096.

Shah, S.K. 2011. Towards Adopting Nanotechnology in Irrigation. Micro Irrigation Systems. India Water Portal: Karnataka, India.

Singh, B. 2014. Protected cultivation of horticultural crops in India - Challenges and opportunities. Agrotechnol., 2(4),1.

Singh, G., Singh, A. K. and Mishra, D. 2007. High density planting in guava. *Acta. Hort*., 735: 235-241.

Singh Y, Prakash S, Prakash O, Kumar D. 2017. Effect of integrated nutrient management on fruit yield and quality of Amrapali mango (*Mangifera indica* L.) under high density planting. *Int. J. Pure Applied Biosci*., 5(3):67-73.

Srinu, B., Rao, M.A., Veenajoshi, K., Reddy, S. and Sharma, H.K. 2017. Studies on Integrated Nutrient Management on Growth Parameters of Papaya (*Carica papaya* L.) Cv. Red Lady under Southern Telangana. *Inter. J. Pure App. Biosci*.,5 (4): 1458-1462.

Srivastava, A., Singh, J.K. and Singh, H.K. 2014. Integrated nutrient management (INM) on growth, yield and quality of papaya (*Carica papaya* L.) cv. CO-7. *Asian J. Hort*., 9(2):390-395.

Sudharshan, G., Anil, P. and Vilas, K. 2017. Effect of fertigation on growth, yield and quality of Nagpur mandarin. *Bull. Env. Pharmacol. Life Sci*., 6 (1):172-176.

Suhasini, S.P., Hipparagi, K., Biradar, I.B., Patil, S.N., Suma, R. andAwati, M. 2018. Effect of integrated nutrient management on growth parameters of Banana cv. Rajapuri. Int. J. Pure Applied Biosci., 6(1):1328-1334.

Surendra, K. V., Singh, J., Singh, R., Payasi, S.K. and Jain, A.K. 2013. Response of ultra high density planting in guava under kyamore plateau in (M.P.) cv. Allahabad Safeda. M.Sc. thesis. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Tagarakis, A., Liakos, V. and Fountas, S. 2013. Management zones delineation using fuzzy clustering techniques in grapevines. *Precision Agric.*,14:18–39.

Tandel, B.M., Ahir, M., Hiray, S. and Patel, K.A. 2017. Effect of integrated nutrient management on yield and quality of papaya (*Carica papaya* L.) cv. Taiwan Red Lady. *Int.J.Chem. Stud*..; 5(4):1901-1903.

Tekinel, O., Kanber, R., Önder, S., Baytorun, N. and Baştuğ, R. 1989. The Effects of Trickle and Conventional Irrigation Methods on Some Crops Yield and Water Use Efficiency Under Çukurova Conditions. Irrigation Theory and Practice. Proceeding of the International Conference, University of Southampton, London, England, 641-651.

Theofanis Gemtosa, Fountasa, S., Tagarakisa, A. and Liakos, V. 2013. Precision Agriculture Application in Fruit Crops: Experience in Handpicked Fruits. *Procedia Technol. 8*, 324 – 332.

Tiwari N, Singh SS, Singh R, Charmkar NK. 2018. Effect of organic cum inorganic sources of nutrients on growth, yield and economical gain from guava. International Journal of Agricultural Sciences and Research. 8(1):79-84.

Vool, E., Ratsep, K., Bachman, U. and Moor. 2013. The quality of grapes in open field and in protected cultivated condition. Innovation horticulture fields of study programs with an emphasis on languages and professional skills and competitiveness of graduates., no. CZ.i.07/2.2.00/28.0220.

Yogesh, P. R., Singh, S. D., Mohan, L., Gopal, S. and Rawat, P. L. 2016. Performance of high density planting of mango (*Mangifera indica* L.) under mid-western plain zone of Uttar Pradesh. *Inter. J. agric. Sci.*,12 (2): 298-301.