High Density Planting in Fruit Crops

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OPEN ACCESS

Keywords

High-density, Rootstocks, Light, Precision, Economics

How to cite this article:

Pradhan, P. K., Ghosh, K., Subudhi, A. K. and Panda, S. 2025. High Density Planting in Fruit Crops. *Vigyan Varta* 6(4): 200-205.

ABSTRACT

High-Density Planting (HDP) is a modern horticultural technique that maximizes fruit yield per unit area by optimizing space. It is vital for food security and has been successfully applied in crops like mango, citrus, guava, papaya, and apple, with ultra-high-density apple orchards reaching 20,000 plants per hectare. HDP relies on dwarfing rootstocks, compact cultivars, growth regulators, and precision pruning to enhance light interception, shoot control, and resource efficiency. The benefits of high-density planting include higher solar radiation use, early yields, lower labor costs, and better fruit quality. However, challenges include high establishment costs, complex maintenance, and pest issues. HDP has transformed global fruit production, with India adopting it in guava and banana, proving its sustainability and economic benefits.

INTRODUCTION

HDP is one of the key strategies for horticulture crops, both short-term and permanent, to attain high yield per unit area. High Density Planting (HDP) is a very intense fruit production method that is highly relevant to our growing population's food and nutritional security. HDP systems for mango, citrus, papaya, and guava have been developed to make effective use of both horizontal and vertical space. The term "High density planting," or HDP, refers to the practice of planting fruit trees closer together than is advised using specific procedures with the primary goal of maximizing yield per unit

area without compromising quality**.** In apple orchards, an extremely high-density planting strategy of 20,000 plants per hectare has just been implemented. As the trees start to produce fruit, techniques to regulate shoot growth and optimize light interception are essential to the technology's success in the majority of fruit crops. In order to efficiently absorb and disperse solar radiation, plant density must be planned with consideration for the climate, cultivar, planting strategy, and management techniques. Enhancing productivity in both qualitative and quantitative dimensions is the goal it seeks to accomplish (Ahmed *et al*., 2022).

Principles of HDP in fruit crops:

Fruit trees are planted tightly in the planting methods with a high density, a contemporary style of fruit farming that enables tiny or dwarf trees with modified canopies for improved light dispersion and interception as well as simpler automated field work. HDP offers a greater yield and return per unit area. Maintaining the tree's size and shape may be achieved by routine trimming and the use of bio regulators. India's diverse soil and temperature allow for the cultivation of a wide range of tropical, subtropical, and temperate fruits in various places, which is why it is considered a horticultural paradise (Ahmed *et al*., 202)). Higher production per unit area is the focus of a shift in the notion of fruit production that has occurred in recent years. A high-density planting strategy is the quickest approach to shorten the gestation time and boost orchard yield. The topography, crop type, plant density, and production method to be used all influence the planting scheme selection in the orchard.

Advantages of High-Density Planting in fruit crops:

1. Compared to traditional low-density planting, high-density planting offers a few clear benefits.
2. HDP enhances the bearing surface per unit of land area and enables greater use of incoming solar energy.
3. High-density orchards are more adaptable to contemporary, input-efficient horticulture practices like mechanized harvesting and drip watering.
4. Using dwarf trees and controlling excessive vegetative growth reduces competition between economic parts and alternative sinks, like supporting structures, and the distance that assimilates must be translocated from source to sink. This leads to early economic returns and increased productivity and harvest index.
5. Horticultural practices like pruning and plant protection measures are easier to implement in high-density planting systems, which not only increases the efficiency of these operations but also lowers personnel costs.
6. Another benefit of high-density planting is that fruits from these trees may be harvested more easily and with less damage, which improves post-harvest life. Additionally, higher fruit quality is a result of optimal sunshine exposure.

Limitations Associated with High-Density Planting:

1. The establishment cost of high-density planting must be greater.
2. A more expert and scientific approach to management is required, as opposed to traditional planting with broader spacing.
3. Overcrowding in high-density plantings can lead to productivity loss from shade,ineffective control of diseases and pests, limited access to the orchard, and higher harvesting expenses.

Fruit crop spacing at various planting systems:

Sl. No	Fruit crop	Regular distances	HDP distance (cm)
1.	Guava	6×6 - 8×8	3×3 - 3×1.5
2.	Aonla	10×10	5×5
3.	Apple	10×10	3×0.75
4.	Mango	7.5×7.5 - 12.5×12.5	3×2.5 - 5×5
5.	Citrus	6×6 - 8×8	3 - 6×3 - 4.5
6.	Sapota	10×10	5×5
7.	Banana	2×2 - 2×3	1.5×1.5 - 1.8×1.8
8.	Papaya	2×2 - 3×3	1.8×1.8

(Source- Ahmed *et al*., 2022)

HDP elements consist of:

High density planting is possible with the appropriate use of following elements:

1. Varieties of dwarf scion.
2. Small interstock and rootstock.
3. instruction and trimming.
4. Utilize growth regulators.

Dwarf scion varieties:

Crop	Cultivars	Desirable features
Banana	Dwarf Cavendish (AAA)	High yielding with dwarf stature
Mango	Amrapali, Arunika	Early and inclined to bear frequently
Papaya	Pusa Nanha, Pusa Dwarf	Small and typically bear at a lower altitude
Peach	Red Heaven	Dwarfing & high yielding
Apple	Spur varieties like Red Chief, Oregon Spur	Bear on short stem, spurs; develop to 60-70% of normal cultivars in vigor and bear more spurs and give more
Guava	Pant Prabhat, Lalit, Allahabad Safeda	Less spreading and high yielder
Cherry	Meteor, Compact Lambert & North Star	High yielding, self-fruitful, Dwarf
Litchi	China	Upright tree growth habit
Sapota	PKM1, PKM3	Dwarf tree stature

(Source- Ahmed *et al*., 2022)

Dwarf rootstocks and inter-stocks:

1. **Plum**- Pixy
2. **Mango** - Vellai kullamban
3. **Sweet cherry** - Mahaleb, Colt, CAB 6-P, CAB -11E, F 12/1, GM-61/1, G-258, F-283, MM 1/5413, GM-9, GM-61
4. **Apple** - M9, M26, M27, Bud. 9, Bud. 146
5. **Guava** - *Psidium friedrchsthalianum*, *P. chinensis*, Pusa Srijan
6. **Almond** - Hansen-2168, GM-677, GF-556, Istara
7. **Cherry** - Colt, Charger and Rubria
8. **Citrus** - Troyer citrange, Flying Dragon (*Poncirustri foliata*), Karna Khatta
9. **Pear** - EM Quince A& C
10. **Apricot** - Citation, Istara, Torinel, Myrobalan
11. **Peach** - Siberian C, St Julien X, P. Besseyi and Rubria

(Source- Ahmed *et al*., 2022)

Training systems of different fruit crops:

Crop	Training systems
Cherries	Central leader, Free spindle, Tatura trellis.
Peach	Tatura trellis, Central leader, Open centre, Modified leader, Pillar, Belgium Fence, Hedgerow and Meadow.
Apple	Espalier, Cordon, Spindle bush, Oblique palmette, Trellis, Vertical axis, slender spindle.
Apricot	Free spindle, Bent canopy, Vase palmette, Kechement hedge and wedger hedge.
Pear	Lincoln canopy, Free standing tree, Pyramid, Spindle bush, Palmette, Tatura trellis.
Plum	Hedge row, Central leader, Open central, Tatura Trellis, Lincoln canopy, Vase palmette.

(Source- Ahmed *et al*., 2022)

Use of growth regulators:

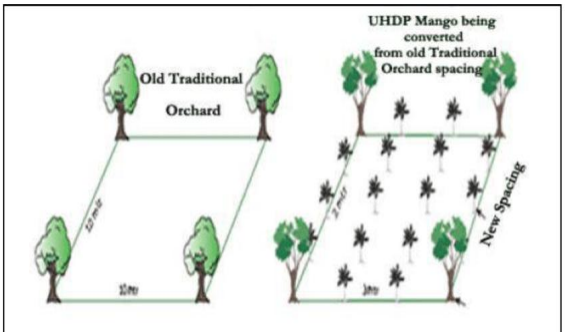
In contemporary orchard systems, chemical growth management is an alluring option due to the dearth of suitable rootstocks for growth control in some fruit crops, like peaches, cherries, etc. Growth regulators such paclobutrazol, ethephon, daminozide, and chlormequat have been used to cut shoot growth by one-third to one-half. It may be helpful in promoting early commercial fruit output in young trees that are sparsely productive and aggressively vegetative. This was followed by enhanced blooming the following year. Paclobutrazol promotes

development, initiates FBD, inhibits vegetative growth, and lessens the juvenile phase.

A comparison between the HDP/Meadow method with the traditional approach for fruit cultivation:

Sl. No	Features	Traditional method	HDP/ Meadow method
1.	Quality	Large canopy, inadequate solar exposure, and subpar fruit.	A small canopy, improved air and sunshine penetration, a low risk of illness, and superior fruits with vibrant color development .
2.	cost of manufacturing	Increased manufacturing costs	Decreased manufacturing costs
3.	Management	The scale of the tree makes it challenging to handle	The tree's tiny size makes it easy to handle
4.	Bearing	After 2 to 4 years	From the first year
5.	Harvesting	Difficult	Easy
6.	The amount of labor needed	need more workers	Need less workers
7.	Manufacturing	Lower yield	Higher yield
8.	number of trees	A small number of huge trees (150–200 trees/ha)	Small trees in large numbers (500–1,000,000 trees/ha)

(Source- Ahmed *et al*., 2022)



(Source –Singh *et al*. 2017**)**

Global Perspective on High-Density Planting:

HDP has been effectively used to a number of fruit crops worldwide, most notably apples. High-density apple orchards have been made easier to grow in temperate locations by the use of dwarfing rootstocks and rigorous canopy control, which has raised output and profitability. Studies show that as compared to conventional planting densities, HDP systems can provide much larger yields (Verma, MK., 2024). HDP has been widely used for several fruit crops in temperate climates. Apple orchards in North America and Europe, for example, have switched to high-density systems that can support up to 10,000 trees per hectare. This change has led to higher yields, better fruit quality, and earlier fruiting. Because of the utilization of dwarfing rootstocks, sophisticated training and pruning methods, and effective resource management, HDP has been successful in various areas (Singh, VK. 2018).

Recent scenario in India of high-density plantings in fruit crops:

Guavas may have up to 5,000 plants per hectare when planted ultra-highly densely, with each plant placed 2.0 x 1.0 meters apart. Higher yields and better fruit quality have resulted from this arrangement in conjunction with methodical pruning and canopy control (Mishra *et al*., 2018). In India, traditional mango orchards are evolving into high-density varieties, with 400–1,600 trees planted per hectare. This change has led to increased yields and early fruiting. In these systems, frequent canopy control and the use of dwarf cultivars are essential procedures (Singh, VK. 2018).

Success story of Indian farmers:

One of the farmers in the project area, Mr. M Venkatesan, had grown the G-9 cavendish variety on a one-hectare plot of land. In the

Dharmapuri area, bananas are grown on around 25 hectares. Mr. Venkatesan saved half of the irrigation water by implementing this system. Below is a list of the key components of the technology he used.

1. Preparing the land
2. Applying 200g of gypsum, 20g of furidon, 5kg of FYM, and 2kg of single super phosphate.
3. Raised beds that were around one foot high were set up.
4. On the elevated bed, cubic pits of around two cubic feet were placed.
5. After being put within the hole, the suckers were covered with dirt and water.
6. Every five days, a irrigate was conducted.
7. There were 3,000 plant species.
8. After planting for two months, side suckers were taken out.
9. Only a single sucker was permitted to develop.
10. To keep the trees from toppling over in the case of wind or rain, stakes were fastened to them in the seventh month.
11. Eight months after planting, a cluster of fruits emerged. It helped to sprinkle the fruit bunches with poly feed at this period.

Economics:

1. The yield from the 11-month crop was 100 tons.
2. The cost per ton was Rs. 8,000. Earned income: Rs. 8,000 x 100 equals Rs. 8,00000.
3. The drip irrigation system cost Rs. 1.15 lakh.
4. Each sucker cost Rs. 11, hence Rs 33,000 (3,000 x 11)

(Source – Kumar *et al*.,2010)

CONCLUSION:

Modern fruit agriculture has seen a revolution with High-Density Planting (HDP), which increases output and conserves resources. Better light interception, more bearing surface, and early financial returns are guaranteed by HDP through the use of dwarfing rootstocks, plant spacing optimization, and systematic canopy management. In temperate countries, where apple orchards have shifted to high-density systems and generated big revenues, the technology has acquired major popularity worldwide. With increased yields and better fruit quality, farmers in India have shown great success with the use of HDP in guava, mango, banana, and other fruit crops. The viability of HDP is demonstrated by case studies, such as the successful adoption of ultra-high-density banana farming by Indian farmers, where methodical management techniques have improved profitability and optimized resource use. HDP's long-term advantages—such as lower labor costs, better pest and disease control, and increased sustainability—outweigh its drawbacks, even in the face of obstacles like high upfront expenses and complicated maintenance. Plant growth regulators, fertigation, and precision pruning have all advanced, and HDP has the potential to completely transform fruit output, guaranteeing farmers' financial stability and food security. The future of intensive and sustainable horticulture may be greatly impacted by the broad adoption of this method, which makes HDP a crucial tactic for increasing fruit crop output.

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