

High-Density Planting in Fruit Crops

High-Density Planting is a very intensive form of horticultural production which has high relevance to the food and nutritional security of our ever-increasing population. HDP system is normally understood as a system in which a higher number of plants are accommodated within a unit area in comparison to the conventional planting density. Hence, interest in HDP in fruit crops has increased considerably in the recent past. Many fruit trees are now grafted onto size-controlling clonal rootstock and planted at much higher densities.

Need for High-Density Planting (HDP)

- ✓ Decline in the availability of cultivable land,
- ✓ Rising energy and land costs
- ✓ increased demand for fruit and fruit products,
- ✓ HDP is one of the techniques to enhance the productivity per unit area both in short duration and perennial horticultural crops.

Principle of HDP

- ✓ To make the best use of vertical and horizontal space per unit time
- ✓ To harness maximum possible returns per unit of inputs and resources.
- ✓ HDP aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without impairing the plant health.

Different Types of Planting

1) Low-density planting:

The non-intensive system, age-old planting system, trees planted at wide spacing, accommodating about 100-250 plants/ha. Dwarfing rootstock is not used. Trees acquire commercial production potential after 10-15 years of planting. Output from orchards during the early 10-15 years is less. Less input and care-intensive hold popularity among growers.

2) Medium density planting

Highly minimized distance covering 250-500 plants/ha. Proper pruning is undertaken to manage trees in desirable shape. More care-intensive, labor requirement is more, obtained yield is also more. Lead in output reliable growers to produce amenable fruit crops like pomegranate, citrus, guava, papaya, banana, etc.

3) High-density planting

Very condensing planting with 500-10,000 plants/ha depending on fruit crop. Medium high density: – 500-1500 plants/ha. Optimum high density: – 1,500-10,000 plants/ha. Ultra-high density: – 10,000-1,00,000 plants/ha.

Relies heavily on rigorous training and pruning. Maintenance of pruning is very heavy. Dwarfing rootstock and chemicals are also used in this system. Yield, as well as expenses per unit area, is high.

4) Meadow orcharding

Meadow-grassland, also known as Ultra-high-density planting. 10,000-1,00,000 plants/ha in order to maintain tree form, severe top pruning is practiced similar to the mowing of grassland. Plants intended to produce yield after 2 years of age. Heavy use of growth regulators as well as pruning.

Advantages of High-Density Planting

- The high-density planting has certain definite advantages compared to conventional low-density planting.
- HDP facilitates better utilization of incident solar radiation and increases in bearing surface per unit of land area.
- High-density orchards have better amenability to modern, input-saving horticultural techniques such as -drip irrigation, mechanical harvest, etc.
- The use of dwarf trees and checking of excessive vegetative growth gives higher productivity and harvest index as well as early economic returns, through reduced competition between economic: parts and alternate sinks such as supporting-structures and through a reduction in the distance the assimilates have to be translocated from source to sink.
- High-density planting system is more amenable to horticultural operations such as pruning and plant protection measures, which reduces the labor cost involved in addition to the increased effectiveness of these. operations.
- Easy harvesting of fruits from such trees with lesser injury results in better post-harvest life, and better fruit quality due to optimum exposure to sunlight is an added advantage of High-density planting.

Limitations Associated with High-Density Planting

- High-density planting needs a higher establishment cost.
- Need for a more professional and scientific approach to management, compared to conventional planting at wider spacing.
- Crowding in high-density plantings can result in restricted access into the orchard, inefficient pest and disease control, increased harvesting costs, and loss of production through shading.

Important Aspects of High-Density Planting

- 1) **Use of Dwarfing Rootstock and Scion Cultivars:** In temperate crops, this phenomenon is well utilized but not fully exploited for sub-tropical and tropical fruits. However, for tropical fruits like mango and guava, high-density orcharding systems have been developed without the use of dwarfing rootstocks. It can be made more efficient by using dwarfing scion and rootstock cultivars which are to be investigated.

Comparison of high density and traditional planting systems in some fruit crops

Name of the crops	Plant distance or spacing (m)	Planting Density (Plant/ha)	Productivity (t/ha)
APPLE			
Conventional	5.0-8.0x5.0-8.0	400-227	30-50
HDP (Jonathan on MM-106)	3.0 X 7.5	2222	68.75
Hedgerow, (Antonovka on <i>M. silvestris</i>)	4.0 X 3.0	832	482
UHDP (Oregon spur on M-106)	1.0 X 0.5	20,000	4100
BANANA			
Conventional	2.0 X 2.0	2500	35-36
HDP (Robusta)	1.2 X 1.2	6944	113.30
HDP (Poovan)	1.0 X 1.0	10,000	99.10
CITRUS			
Conventional	8.0 x 8.0	227	10 – 15
Conventional	6.0 x 6.0	156	10-15
HDP (Kinnow on <i>Karna Khatta</i>)	3.0 x 3.0	1088	
HDP (Kinnow on Troyer citrange)	1.8 x 1.8	3000	
HDP (Valencia on Carrizo)	3.3 x 1.5	2020	39-50
GUAVA			
Conventional	6.0 x 6.0	277	15.70
HDP (Allahabad Safeda on Pusa Srijan)	3.0 x 3.0	1111	20.43
HDP (Lucknow-49)	2.0 x 2.0	2500	30.64
Ultra-HDP (Meadow orchard) (Lalit & Allahabad Safeda - responsive varieties)	2.0 x 1.0	5000	12.5 (1 st year) 45 (after 4 th year)
MANGO			
Conventional	10.0 x 10.0	100	8.0-10.0
Medium Density Planting	5X5 or 6x6	400 or 278	14.0 – 18.0
HDP (Dashehari)	3.0 x 2.5	1333	25.92

HDP (Amrapali)	2.5 x 2.5	1600	24.46
PAPAYA			
Conventional	2.0 x 2.0	2500	40 - 50
HDP (Pusa Nanha)	1.2 x 1.2	6944	115
PINEAPPLE			
Conventional	-	27,777	49.40
HDP (Kew)	25 x 45x 90 cm ³	70,588	139.83

Use of genetically dwarf scion cultivars

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

Use of Dwarfing Rootstock

Crop	Dwarfing Rootstock
Apple	M9, M26, M27, Bud.9, P22 & Ottawa3
Pear	Quince C
Peach	Siberian C, St Julien X, Prunus besseyi and Rubira
Plum	Pixy
Cherry	Colt and Charger
Mango	Vellaikolumban, Olour, Kurukkan, Nekkare, Bappakai, Totapuri Red Small
Citrus	Citrangquat, Feronia and <i>Severinia buxifolia</i> , Troyer citrange, Flying Dragon (<i>Poncirus trifoliata</i>), Karna Khatta, Rough lemon, Rangpur lime, etc
Guava	<i>Psidium friedrichsthalianum</i> , <i>P. pumilum</i> , Pusa Srijan
Ber	<i>Zizyphus rotundifolia</i> , <i>Z. nummularia</i>

- 2) **Use of Clonal Rootstock:** It is generally believed that clonal rootstocks are dwarf in nature and produce uniform trees which can be utilized for high-density orcharding. However, most of the tropical and subtropical fruits are not having clonal rootstocks and are difficult to propagate vegetatively, except for a few like litchis where no rootstock is used traditionally. Mostly tropical and subtropical crops are poor in rooting and not highly suitable for propagation by cutting. Therefore, annual pruning can be adopted and further work is done to produce clonal rootstock.
- 3) **Pruning:** Pruning has been applied successfully on mango, guava, and litchi. It has a great promise to keep fruit trees dwarf and make them suitable for high-density orcharding. This method can be applied to other crops also.
- 4) **Use of Growth Retardants:** Growth retardants have been used for high-density orcharding with or without dwarfing rootstock or scion cultivars. It has been tried in apple, peach, plum, citrus, and mango. For several other fruit crops like mango, peach, pear, apple, etc. where dwarfing rootstock or scion cultivar is not available, chemicals like paclobutrazol (Cultar®), AMO 1618, and XE 1019 are applied.
- 5) **Training system:** Central leader, modified leader, and open central training systems were followed in conventional orchards. Many new training systems like cordons, palmette form, Hedgerow planting, spindle bush, modified spindle bush, dwarf pyramid, and different trellises like Tatura, Panstate low trellis have been developed for high density. These systems were mostly developed and applied to temperate fruit crops. Their feasibility in tropical and subtropical areas needs investigation.
- 6) **Light Interception:** Fruit quality is directly proportional to light interception by the trees in the orchard. Light interception is affected by several factors as given below:
- 7) **Planting Density:** Light interception by the orchard is directly affected by the planting density. Maximum light interception by planting trees too closer may also reduce quality. Thus, the optimum density is needed to balance yield and fruit quality.

Spacing at different planting system in fruit crops

Sl. No.	Crop	Normal spacing (m)	HDP spacing (m)	Meadow spacing(m)
1.	Mango	7.5 X 7.5 - 12.5 X 12.5	3 X 2.5 – 5 X 5	2.5 X 2.5 - 3 X 1
2.	Banana	2 X 2 - 2 X 3	1.5 X 1.5 - 1.8 X 1.8	1.2 X 1.2 - 3 X 0.5
3.	Citrus	6 X 6 – 8 X 8	3 -6 X 3 -4.5	-
4.	Papaya	2 X 2 – 3 X 3	1.8 X 1.8	1.2X1.2 - 1X1
5.	Gauva	6 X 6 – 8 X 8	3 X 3 – 3 X 1.5	2X2 - 2X1
6.	Sapota	10 X 10	5 X 5	-
7.	Aonla	10 X 10	5 X 5	-
8.	Apple	10 X 10	3 X 0.75	3 X 0.37 - 0.60

- 8) Canopy Management:** Tree canopy management affects fruit yield and quality by affecting light interception. The canopy geometry should be managed in such a way that it intercepts maximum light. For high density, a shallow canopy (1.5-2.0m in depth) is needed to achieve -maximum efficiency for trapping sun energy through foliage and channelizing metabolites for quality fruit production with maximum returns.
- 9) Row Orientation and Rectangularity:** The effect of planting density on light interception can be modified by the row orientation and rectangularity. North-South orientation and rectangular plantings intercept maximum light than East-West and square orientation.
- 10) Management of Canopy Volume:** In most tropical and subtropical fruit crops, only the outer canopy area of 1.0m in depth bears fruits. Under high-density orcharding, trees cover the area between them early and total canopy volume per unit area is more in case of high density than normal density planting which enables high early yields with high profits.

Comparison between Traditional system and HDP/Meadow system of fruit growing

Sl. No.	Attributes	Traditional system	HDP/Meadow system
1.	Tree numbers	Few large trees/ha (150-200 trees/ha)	Many small trees/ha (500-1,00,000 trees/ha)
2.	Bearing	After 2 to 4 years	From the first year
3.	Production	Lower yield	Higher yield
4.	Management	Difficult to manage due to large tree size	Easy to manage due to small tree size
5.	Labour requirement	Requires more labour	Requires less labour
6.	Production cost	Higher cost of production	Lower cost of production
7.	Harvesting	Difficult	Easy
8.	Quality	Large canopy, poor sunlight penetration and poor-quality fruits.	Small canopy, better air and sunlight penetration, minimum disease incidence and high-quality fruits with good colour development

High-Density Orcharding in Mango

Important Practices followed in Mango HDP

Amrapali mango (1600 plants/ ha).

- ✦ Germinate mango stones *in situ* at the planting distance of 2.5 k-2.5 meters.
- ✦ Graft rootstock seedlings *in situ* with Amrapali
- ✦ Apply 10 kg of FYM and 0.5 kg fertilizer mixture (ammonium sulfate, single super phosphate, and sulfate of potash in a 1:3:1 ratio) in the first year.
- ✦ Increase doses of FYM by 10 kg FYM each year up to seven years age of the tree and that of fertilizer mixture to 1.0 kg during the second and third year, to 1.5 kg during the fourth and fifth year, and to ZO kg later on
- ✦ Apply the full quantity of FYM during October, whereas, fertilizer mixture in a single dose in July up to three years and subsequently in two split doses (first after harvest and the second in September)
- ✦ Irrigate trees at the fortnightly interval -during summer and at the monthly interval in winter during a non-fruiting stage. Irrigate bearing trees at fortnightly interval- from the marble stage of fruit-to-fruit maturity.
- ✦ It was observed that after 11 years of planting yield of the orchard was drastically reduced due to the overlapping canopy of adjoining trees. Therefore, exercise judicious pruning to manage the canopy and remove intermingling branches which allow proper sunlight penetration and result in better yield and quality.
- ✦ Expected yield 20-24 tonnes per hectare.



HDP in Mango

Comparative details of high-density over the traditional system in terms of estimated investment, net returns, etc.

Particular	Traditional system	High-density planting
Spacing (m)	10 x 10	2.5 m x 2.5 m
No. of plants/ha	100	1600
Cost of establishing orchards	Rs. 35,000	Rs. 75,000
Annual maintenance cost	Rs. 25,000	Rs. 40,000
Age of stable yield	8 to 10 years	7 to 8 years
Production (kg/ha)	6,000 to 8,000	16,000 to 19,000
Sale of produce (wholesale) @ Rs. 9.0 per kg	Rs. 54,000 to 72,000	Rs. 1,44,000 to 1,71,000
Net Return	Rs. 29,000 to 47,000	Rs. 1,00,000 to Rs 1,30,000