

A detailed review on: High-Density Planting and Canopy Architecture Management in Tropical Fruits

Yashika¹, Deepak Lal² and Siddesh Alavekar³

Research Scholar¹, Assistant professor² and Ph.D. Scholar³

Department of Horticulture, Faculty of Agriculture (FoA)

Naini Agricultural Institute (NAI)

Sam Higginbottom University, Technology and Sciences (SHUATS)

Naini, Prayagraj, Uttar Pradesh, India 211007

Corresponding author: tiwariyashika2004@gmail.com

ABSTRACT

High-Density Planting (HDP) and canopy architecture management are key strategies in tropical fruit production to enhance productivity and resource-use efficiency. Traditional orchards with wide spacing and large canopies often yield less because of poor light, water, and nutrient use. HDP accommodates more plants per unit area without affecting growth or quality, improving solar radiation use, photosynthesis, and yield. It has shown great success in crops like mango, guava, banana, papaya, and citrus by using dwarf rootstocks, tissue-cultured plants, and optimized spacing for earlier, higher returns. (Chadha & Pal, 2013; Singh H.P. & K.L Chadha, 2002) Canopy management complements HDP by maintaining ideal light and airflow through training, pruning, and growth regulation. This improves fruit quality, reduces pests and diseases, and facilitates mechanization. Systems like open-canopy (mango) and hedge-row (guava, citrus) maximize light interception and ease harvesting. Together, HDP and canopy management can increase yields 2–3 times over traditional systems and ensure early profitability. Successful implementation depends on suitable cultivar selection, soil fertility, irrigation, and consistent canopy regulation. (Lakshminarayana & Subhadra Bandhu, 2001; Mitra, 2016; Singh J.P. & Reddy, 2011 Tiwari & Lal, 2014)

Keywords: High density planting, canopy architecture, tropical fruits, sustainability, fruit quality, precision horticulture.

INTRODUCTION

HDP is one of the important methods to achieve high productivity per unit area in both short-duration and perennial horticultural crops. High Density Planting (HDP) is a very intensive form of fruit production which has high relevance to the food and nutritional security of our ever-increasing population (Anon. 2010). For efficient use of horizontal and vertical space, HDP technologies have been developed in mango, citrus, papaya and

guava. Planting of fruit trees rather at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity per unit area without sacrificing quality is often referred as 'High density planting' or HDP. Recently, super high-density planting system has been also established in apple orchards with a plant population of 20,000 trees per ha (Usha et al 2015).

The success of this technology in most of the fruit crops is dependent on the use of methods to control shoot growth and maximize light interception as the trees begin to bear fruit (**Menzel and Lagadec, 2014**). Plant density needs to be designed to intercept and distribute the solar radiation effectively keeping in view the climatic conditions, cultivar, planting system, and management practices. It aims to achieve the objective of enhanced productivity in both qualitative and quantitative aspects.

Principle of HDP

- To make the best use of vertical and horizontal space per unit time.
- Increased capture sunlight per unit area.
- To harness maximum possible returns per unit of inputs and resources.
- Land use efficiency.
- Appropriate vegetative reproductive balance of the plants.

High density planting in fruit crops

High density planting technique is a modern method of fruit cultivation involving of fruit trees densely, allowing small or dwarf tree with modified canopy for better light interception and distribution and ease of mechanized field operation. HDP gives higher yield as well as return/unit area. It is possible by regular pruning and use of bio regulators for maintaining the size and shape of the tree. It is well known that the diversity in soil and climate conditions in India permits growing of a large variety of Tropical, Subtropical and Temperate fruits in different regions, due to which India is regard as a horticultural paradise. In recent years, the concept of fruit production is undergoing a change where emphasis is being given to higher

production per unit area. High-density planting system is the fastest way of reducing the gestation period and increasing the productivity of the orchards. The choice of the system of planting in the orchard depends on topography, crop variety, and plant density.

Canopy architecture management

Canopy management is one of the most important fruit plant management practices. This forms the basis of the precociousness and longevity of the fruit trees in an orchard. The strong scaffold system helps the trees to produce heavy crop loads of quality fruits without any major limb breakage, for example, patharnakh. Some trees bear regularly only if pruned every year, for example, peach and grapes. Regular annual priming is essential for the induction of a good amount of new growth, which will provide the tree with maximum fruit bearing area uniformly over the whole tree. Unpruned trees grow beyond limits provided for each tree in an orchard. The branches start intermingling with the branches of adjacent trees giving an impression of a jungle. The photosynthetic activity of the trees gets adversely affected leading to the poor yields of low-quality fruits. Orchards become economically unproductive. To keep the fruit trees within the area provided for their spread for the whole of their life, canopy management is of prime importance. Many factors go into the production of fruits. One factor is the optimum quantity of light. When the fruit tree absorbs the right amount of sunlight, it can produce high-quality fruit. It is therefore essential for a fruit farmer to pay attention to the tree canopies. And this is where canopy management plays a role.

(**Nath & Das 2018**)

Principles of Canopy Management

The aim is to induce trees to maintain a balance in between vegetative and fruiting wood, with uncrowded bearing wood situated conveniently within the relative shelter of the well-lit, adequately ventilated inner canopy.

- Maximum utilization of light
- Avoidance of built-up microclimate congenial for diseases and pest infestation.
- Convenience in carrying out cultural practices.
- Maximizing productivity with quality fruit production.
- Economy in obtaining the required canopy architecture.
- Induction of complexity in young trees.
- Maintenance of complexity in bearing trees.
- Reduction of the complexity of large, old trees declining due to the effects of age and/or shading.

Objectives of Canopy Management

- To restore root/shoot ratio.
- To obtain specific form of the plant.
- To develop specific geometry within the plant and its overall topology.
- To maintain an optimum balance between vegetative and reproductive parts.

Architecture of Canopy Management

Basic Method:

- a) Training
- b) Pruning

Training

It involves bending or tying branches to achieve a desired shape. In horticulture, training refers to the process of directing and controlling the growth of plants to

achieve desirable shapes, sizes, and yield. This involves physical manipulation of the plant, including bending, tying, and pruning. The goal of training is to create a strong framework of branches that can support the weight of the fruit, and to ensure that the plant receives adequate sunlight and air circulation.

The Training Is Done with The Following Objectives:

- To admit light up to the centre of the tree and provide sufficient movement of air across the plant.
- To increase photosynthetic activity by exposing leaves to the sun.
- To provide a strong scaffold system that could bear the heavy load of fruits, without limb breakage.
- To growth of the tree so that various cultural operations such as spraying, hoeing irrigation and harvesting are performed at the lowest cost.
- To secure balanced distribution of fruit-bearing parts on the main limbs of the tree
- To protect the tree from wind damage

Training Can Be Classified into Several Types, Including:

- Central Leader System: The central leader is allowed to grow uninterrupted. The secondaries grow on the central axis on all directions. The fruit tree grows in a natural way. The tree trunks become very strong due to the spread of many scaffolds and secondaries. (Pathak & Mitra, 2010; Singh R. & Rao, 2015) The trees become tall and spread mostly unmanageable at maturity. This system is most suited to litchi and mango.

- **Modified Leader System:** The central leader is allowed to grow to produce 3-4 side branches, then it is headed back at 75 cm height for low-headed and at 90 cm for high headed plants. In the next year, the top bud sprouts to take the shape of the central leader, which is again headed back after getting 2-3 scaffolds at the last scaffold giving it an open centre. This can be done after 2-3 years of removal of the central leader that is why the system of training is called modified leader system of training. In all, there can be 5-7 scaffolds on which secondaries are made to develop by removing apical dominance of each scaffold periodically. Thus a tree takes the shape of an umbrella in spread and a cone in height. Modified leader system trees possess a strong durable framework like central leader system and openness of the open-centre system. Trees do not grow as tall as in central leader system, thus remain manageable for a long time. Orchard efficiency is never adversely affected due to overgrowth. There is no breakage of limbs due to the load of the fruits. This system is suited to pears, peaches, guava, mango, litchi and many more which can grow to form big trees.
- **Open-centre System:** The plants are planted in the orchard and simultaneously headed back to 75 cm height. The well placed 4-5 side branches are allowed to develop on the main axis. The top growing axis is again cut and is not allowed to resprout and give side branches.

The selected scaffolds are made to produce secondaries and tertiaries just like in modified leader system. Thus, the tree gives the appearance of the umbrella. The limbs can cause breakage on the small main axis due to over weight of fruit on few scaffolds in comparison to modified leader system. Pruning involves removing parts of the plant, such as branches and leaves, to control the size and shape of the canopy. Pruning is the process of selectively removing certain parts of a plant, such as branches, buds, or roots, to improve plant growth, yield, or appearance. It is a common practice in horticulture and agriculture and is done for various reasons, including training plants to grow in a particular shape or size, increasing fruit production, improving plant health, and removing diseased or dead plant tissue.

The Pruning Is Done with The Following Objectives:

- To remove the apical dominance for encouraging branching.
- To remove unproductive over crowded branches.
- To remove diseased and dead wood branches.
- To encourage vegetative growth.
- To control the overall size of the fruit tree.
- To regulate fruiting for regular cropping.
- To give particular training.

Pruning Can Be Classified into Several Types, Including:

- **Thinning out:** This involves selectively removing branches from a tree or plant to improve light

penetration and air circulation. (Pathak & Mitra 2010) Thinning helps to reduce overcrowding, which can lead to competition for resources and a decrease in plant health.

- **Heading back:** When only one-third to one-half of the terminal portions of the branches, having their basal portion intact, are removed. (Singh & Rao, 2015) Such pruning encourages development of secondary branches, lateral bud growth and destroys apical dominance of twig, shoot or branch.
- **Dehorning:** It consists of removal of all the wood after leaving 7-10 cm thick stub all over the tree. Such severe treatment should normally not be given except when it is the last resort to bring it into control.

CONCLUSION

In conclusion, high-density planting and canopy architecture management together represent a modern, sustainable, and resource-efficient approach for tropical fruit production. These strategies align with the global vision of precision horticulture, ensuring higher productivity, better fruit quality, and reduced production costs. Future research must focus on developing dwarf varieties, compatible rootstocks, mechanized pruning and harvesting technologies, and decision-support tools for canopy modeling under tropical conditions. Such interventions will not only optimize fruit production systems but also ensure long-term sustainability, profitability, and resilience of tropical orchards under changing climatic scenarios.

REFERENCES

Chadha, K. L., & Pal, R. K. (2013). *High density planting in fruit crops* –

Experiences and expectations. Indian Horticulture, 58(1), 3–7.

Kumar, R., & Singh, S. (2016). Canopy management in fruit crops: Principles and practices. *Indian Journal of Horticulture*, 73(1), 1–9.

Lakshminarayana, K., & Subhadra Bandhu, S. (2001). *Tropical fruits*. CABI Publishing.

Mitra, S. K. (Ed.). (2016). *Agro-techniques of tropical and subtropical fruits*. Springer

Nath, V., & Das, B. (2018). Technological advances in canopy management of fruit crops under high-density planting system. *Journal of Applied and Natural Science*, 10(2), 756–764.

Pathak, R. K., & Mitra, S. K. (2010). Meadow orchard system in guava: A novel approach for high productivity. *Acta Horticulture*, 849, 367–372.

Singh, H. P., & Chadha, K. L. (2002). Principles and practices of high-density planting in fruit crops. *Indian Council of Agricultural Research, New Delhi*.

Singh, R., & Rao, M. M. (2015). Canopy architecture management in mango for higher productivity. *Acta Horticulture*, 1066, 49–56.

Singh, J. P., & Reddy, Y. T. N. (2011). High-density planting and canopy management in tropical fruits. In K. L. Chadha (Ed.), *Advances in Horticulture: Fruit Crops* (Vol. 2, pp. 317–342). *Malhotra Publishing House*.

Tiwari, R., & Lal, S. (2014). High-density planting system in guava (*Psidium guajava* L.): A review. *Progressive Horticulture*, 46(2), 257–262.
