

High density planting system in apple using clonal rootstock: A profitable venture

With the reduction in average land holdings, shifting from low density planting systems to high density planting systems is need of the hour, as the trees under these systems are more precocious, heavy yielders and produce better quality fruits. One of the key advantage of these systems is the distribution of light which is equally distributed over the canopy and each fruit gets optimum light for better colour development. It allows most of the work to be done from the ground itself and also gives an opportunity for mechanization which will reduce the amount of labour capital later required.

HIGH-DENSITY planting refers to the planting of higher number of plants per unit area than the conventional system of plantings. Conventionally, standard apple plants raised on seedling rootstocks are planted at a spacing of 7.5×7.5 m and spur varieties at a spacing of 5.0×5.0 m with a planting density of 178 and 400 trees/ha respectively. The average productivity of these orchards is approximately 6-8 metric tonnes/ha, which is much below the productivity obtained in high-density orchards (40-60 metric tonnes per hectare) where the density of plant will be approximately 500 to 600 trees/acre. High-density orcharding can be done on flat and fertile lands with assured irrigation using dwarf/semi-dwarf clonal rootstocks which can be trained to modern methods of canopy management, viz. Tall Spindle, Vertical Axis and Slender Spindle, etc. This technology is helpful in best utilization of land and other required resources and ease in orchard inter-culture operations, plant protection as well as harvesting and to obtain export quality of the produce. High-density systems will be productive and

profitable if it is managed very well with several very specific considerations as discussed here stepwise.

Selection of variety

When high chill varieties like Royal and Red Delicious are grown on lower altitude, they do not develop colour which is the major challenge for their commercial exploitation at intermediate or mid hill region. Varieties having chilling requirement of 700-900 hours like Jeromine, Red Velox, Red Cap Valtod can be grown at medium altitude of 1200-1800 m.

Altitude (m)	Variety recommended
1200-1800	Early Red One, Gale Gala, Jeromine, Red Velox, Redz Cap Valtod, Scarlet Spur II, Redlum Gala, Super Chief
1800-2200	Auvil Early Fuji, Oregon Spur II, Vance Delicious
2200-2400	Fuji, Red Chief, Royal Delicious, Top Red

Highly feathered nursery trees: If procuring nursery trees, ideally it should have 10-15 feathers/tree. Transplant shock caused by a high top to root ratio helps to keep trees within this tight spacing. It also contributes to significant fruit bud differentiation at the year of planting.

Selection of pollinizer variety

As in traditional system, we are using Golden Delicious and Red Gold as pollinizer, which do not fetch good price in market. New pollinizer variety like Gale Gala, Redlum Gala and Auvil Early Fuji are getting good market price and they can also be planted in the 33-40% ratio to increase the fruit set percentage and overall productivity. One of the major advantage of these pollinizing varieties is the synchronization of their flowering pattern with commercial variety. Auvil early Fuji is also a good pollinizing variety which is recommended for higher elevation as it does not develop colour at lower elevation.



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Variety	Rootstock to be used	Planting distance	Training system
Gala, Redlum, Red Velox	M 9 (dwarfing rootstock) for standard or semi-spur variety	2.5 × 1.0-1.5 m	Tall spindle
Red Cap, Valtod, Super Chief, Scarlet Spur	MM 106 (semi-dwarf) / MM 111 (semi-vigorous) for spur bearing variety	3 × 1.5-2 m	Tall spindle



Bending of branch below horizontal in Tall spindle training system

Use of dwarfing rootstock

The other important consideration is the use of appropriate dwarfing rootstocks which is the key component of high density planting system. The most successful high density orchards established to date have been on M.9 and B.9 rootstock. The yield efficiency and precocity of the Geneva rootstock are also being stated positive where fire blight is a concern. More vigorous rootstocks than these should only be used with the weakest growing varieties such as Spur Delicious. Malling 9 is an excellent rootstock for this system as are G.41, G.11, G.16, V2 and V3. Malling 26 rootstock should only be used for weaker growing varieties. The base of the tree where the rootstock has been planted should be approximately six inches above the soil.

Planting distance

It depends on the vigour of variety and rootstock and also on the soil strength. In high density orchards the density of plant should be approximately 500 to 600 trees/acre. The maximum spacing between trees should be 4-6 feet and 8-12 feet between rows depending on the elevation and the terrain of the land.

Training system

In high density orcharding, trees should be trained to modern methods of canopy management, viz. Tall Spindle,

Vertical Axis and Slender Spindle, etc.

Tall Spindle: In tall spindle system of training, our target should be to grow a tall narrow tree with a straight leader up to the top wire and a fruiting area well exposed to the sun. For it the ideal nursery tree should be at least 5 feet tall and preferably 6-7 feet. This tree should have an abundance of healthy roots and a dominant straight leader. It should have 8-12 feathers that are 15-30 cm long and they should be distributed at regular intervals along the leader. The maximum spacing between trees should be 4 feet and 12 feet between rows depending upon the vigour of rootstock and variety. The optimum Tall Spindle spacing for an average vigour variety and soil is 3 feet by 11 feet. While planting the lowest feather should at least be 60 cm above the soil and rootstock should be 10-15 cm above ground level. Pruning the new tree is discouraged therefore tying and training are more useful to encourage the healthy growth and to produce fruitful feathers.

This is very different from planting conventional orchards system where new trees are planted as whips and severely pruned to encourage strong growth. During the 1st year of tree training the leader is not cut and after bud break, competing side shoots near leader along with broken or damaged branches are removed. Any feathers lower than 50 cm are also removed. The feathers having diameter more than 50-66% of leader diameter should also be removed. This is very critical as we need to maintain the dominance of the leader. These branches whose diameter is exceeding the diameter of leader should be cut with bevel cut which will encourage the new growth from below the cut.

Tying down of feathers below horizontal is the most important aspect of tall spindle. Then the support system is installed at planting and trees are attached to it. Our goal during first year should be to let the leader grow as tall as possible so that it should be reaching top in the 2nd or 3rd year itself. In the initial 1-2 years the trees energy is directed to growth towards the top wire and producing many feathers that will crop early.

Vertical axis: This system of training is also similar to tall spindle besides here the branches are maintained just horizontal unlike tall spindle where they are managed below horizontal. This system also relies on high density, dwarfing rootstocks, minimal pruning, limb renewal, and an effective support system. The major disadvantage is that it is a tall system that requires working off the ground. Maintaining sufficient vigour in the bottoms and controlling excess vigour in the tops is a challenge in some varieties.

Slender spindle: This system is bit difficult to develop as compared to above discussed systems. After one year of the development of initial basic system the leader is bended and then new branches will develop on that side and at the end of year then the leader will be



Use of cloth pins for branch alignment

bended in opposite direction of first bend and it will also bear branches on alternate side and top canopy will look like S-shape. This system is generally preferred by those growers who wish to work exclusively from the ground level only and are not confident in building the wire support systems. In this system, each tree is supported with a wooden stake 8 feet long and 3 inches in diameter. The tree is pruned to develop a narrow conical shape and excess vigour of the tree top is controlled by annually cutting of 2-year old wood to remove the top most 2 or 3 limbs, which are generally too vigorous. The side limb is tied to the post which will result in a zigzag shape. There are 4 or 5 permanent limbs in the lower part of the tree and young temporary limbs in the top half of the tree.

Use of support system

As the rooting system of M 9 rootstock is brittle and shallow and need support system to maintain the sturdiness of plant, inadequate support system cannot support the weight of the tree and the fruit especially if we get heavy winds and snow storms then the entire system will collapse. Depending upon the training system, different support system can be used. We can use 8 to 10 foot long angle iron, and bamboo pole. The objective is to support the tree and the fruit load within the second or third year. Many times a multiple wires system having wires at 2, 4, 6, 8 and 10 feet interval are tied especially for M 9 rootstock.

Irrigation and fertilizer application

Another key criterion with high-density systems is an efficient irrigation system where we can use micro

sprinklers and drip irrigation system. Fertigation can also be done where soluble fertilizer are being added to the irrigation water and are applied straight-away with irrigation water. Water soluble fertilizer like urea, MOP or 19:19:19 (contains 19% Nitrogen, 19% Phosphorus and 19% Potassium) can be applied with irrigation water as fertigation. Non water soluble fertilizer like single superphosphate should be applied as basal dose. Deficiency of micronutrients like B, Zn, Mn and Cu should be corrected through foliar application of boric acid (0.1%), zinc sulphate (0.5%), manganese sulphate (0.3%), and copper sulphate (0.3%) respectively. One important care need to be taken that manganese sulphate and copper sulphate should be applied by mixing with lime (0.5%).

Special pruning techniques

Special pruning techniques such as pinching, notching, clicking and bending need to be done to maintain the balance between the vegetative and reproductive growth and to have more branches at desired place. The use of plant growth regulator like 6-BA (6-benzyladenine) is very effective in stimulating buds to break. Promalin is also applied to buds where lateral shoot growth is desired. All of these methods can provide a better alternative than using a heading cut for inducing branching on the leader.

Minimal pruning at planting: For HDP system of planting very little growth is needed to fill the available space. Pruning is limited to only the removal of a few larger branches along the leader. Generally, those branches which are more the $\frac{1}{2}$ - $\frac{2}{3}$ rd the diameter of the leader at the insertion point are removed. Pruning in subsequent years is limited to complete limb renewal by removing all dominant limbs.

Bending of branch: Bending is done in tall spindle system of training to reduce the vigour of a branch. Branch weights, rubber bands, or tying can be done for bending. Bending of branch will check the vegetative vigour and will keep the trees within allotted space, and encourages the production of fruit buds for the following growing season.

Limb renewal: All scaffolds are renewed by complete removal if they become too large for the available space and become out of balance within the tree. Renewal cuts



Use of bamboo pole as support system



Use of multiple wire as support system

are made using the standard method of using a “bevel cut” which encourages new shoots to form as replacement fruiting limbs. Tall Spindle differs from most other systems in that there are no permanent limbs within the tree.

Girdling and notching: In notching, partial ringing of a branch above a dormant lateral bud is done to increase the flowering shoots and to induce spur from bud. In girdling, the 2-3 mm strip of bark is removed. Apples produce auxin—a plant growth hormone, in their growing apical meristems and shoot tips. It flows down inhibiting bud break for a distance below the growing shoot tip. A shallow cut into the cambium and phloem interrupts the flow of auxins to the dormant buds and these buds will start to grow. The best time to girdle or notch is in late February to the beginning of March when the sap is starting to flow. These are very effective methods to reduce the tendency towards blind wood. Girdling should be done approximately every foot of the trunk on second year trees.

Summer pruning and pinching: This technique can be used to remove shoots that are growing too much. It can be performed by pinching the shoot apex to reduce shoot elongation. Pinching of shoots at 8-10 cm growth is also carried out to develop the fruiting spurs and to check the growth of branches.

Clicking: Clicking is a method of tipping the branches of one-year-old wood where we will remove 3-5

cm tip portion of such branch. This helps to minimize blind wood. In some varieties bending tends to result in 2-3 more nodes of blind wood. This blind wood not only reduces fruiting potential but also exposes the branch to sun and sunburn due to the fruit orientation and then clicking type pruning methods should be use to counter it.

Spur pruning: It is a good way to rejuvenate trees that are heavy spur bearers such as Red Delicious and Empire. A tree will produce its highest quality fruit on spurs that are 2-5 years old. Any spur that is older than 5 years reduces reduced quality fruit and should be removed. Some spur removal with pruning should be done every year on trees older than five years. The age of a spur can be determined by its size. Spurs on the bottom of limbs should be removed, as they will never produce high quality fruit. Spur pruning initiates new shoot growth to produce new fruiting wood.

Thinning of flower: As on an average, one spur bear 5 flowers, retain only 1-2 fruit after fruit set so that fruit could attain good size and quality.

For further interaction, please write to:

Rajender Kumar, Department of Horticulture, GBPUA&T, Pantnagar 263 145, Uttarakhand. *Corresponding author e-mail: rajenderkumargbpuat@gmail.com
