Review Article

High density planting and meadow orcharding in guava

ABSTRACT

The traditional system of cultivation has posed problems in attaining desired levels of productivity due to large tree canopy. Hence, a need arose to improve the existing production system besides impressing its productivity. Currently, there is a worldwide trend to plant fruit trees at higher density or meadow orcharding to control tree size and maintain desired architecture for better light interception and ease in operations such as pruning, pest control and harvesting. The meadow orchard system is a new concept of guava planting at a spacing of 1mx2m, giving densities of 5000 trees ha$^{-1.}$ This system is designed to produce fruit from first year and regulated to produce a simpler and smaller structured framework rather than traditional well branched trees. In guava, plants are induced to form fruit buds in their first year by topping and hedging. Tree canopy dimension was minimized by regular topping and hedging. Trees flowered and bore fruit in the first year of planting.

Keywords: Ultra high density, meadow orcharding, guava, Pant Prabhat, traditional system.

Introduction

Guava is one of the most referred and legendry fruits because of its hardy and prolific bearing nature even in marginal lands, high vitamin C content specially in fruit peel at mature stage and more income without much care and input. Besides Vitamin C, the fruit is also a rich source of Vitamin A, Vitamin B2, Vitamin B1 and fibres as compared to other fruits. The whole guava fruit is a moderately rich source of calcium, fair source of phosphorous and a good source of iron. Considering all the factors, it is also called as “Poor man’s apple or Apple of the tropics”. It is the fifth most widely grown fruit crop of India and is grown in an area of about 2. 85 million hectares, with an annual production of 3. 72 MT (NHB, 2020-21). But, of late, this crop has exhibited a paradigm shift in the production system, from subsistence farming to commercial production. Tree spacing is one method used to obtain efficient and profitable land use; its basic function is to confine the exploitation zone of the plant with regard to light, water, and nutrients, so the highest total yield position can be reached in the smallest possible area. With ever increasing land costs, and the need for early returns on invested capital, there is a worldwide trend toward high density plantings/meadow orcharding or super intensive or ultra high density planting.

The increasing importance of guava as a commercial tropical fruit crop, both for table purposes and processing, demands its widespread cultivation ensuring regular cropping and higher production. Generally, guava is cultivated using a traditional planting system, under

which it is difficult to achieve desired levels of production, because large trees provide low production per unit area and need high labour inputs. Moreover, large trees take several years before they come into bearing and overall cost of production per unit area is further increased. Hence, there is an overriding need to improve the existing planting system. There is currently a worldwide trend to plant fruit trees on permanent high density planting, meadow orchards and to manipulate tree growth using canopy management to control tree growth patterns and tree shape and maintaining high fruit production of desired size and quality.

Meadow orchard system

The meadow orchard is a modern method of fruit cultivation using small or dwarf trees with modified canopy. Better light distribution within the tree canopy is accepted as a result of more than twice a pruning/year. This condition induces a high rate of canopy photosynthesis that leads to high yield per unit area however; no attempt has been made to develop a meadow orchard system in India for guava production despite its apparent and imminent advantages. Scientific advances in physiology and horticulture are critical for this transformation but the principal factor that makes this transformation possible is topping and hedging for dwarfing. In fact, guava responds well to canopy architecture, which embodies pruning and training, and is one the most suitable for meadow orcharding system Singh *et al.*, 1995. To meet this challenge, CISH, Lucknow has developed a meadow orchard system for guava for the first time in India which accommodates 5000 plants per hectare (1mx2m) with regular topping and hedging, particularly during the initial stage. The modern system of fruit growing which has been developed over the years for temperate fruit production can be employed for guava fruit production with certain modifications. These systems basically involve the planting of small trees with high density, controlling height simply by topping and hedging (pruning). The reason for this was the necessity to achieve early cropping with high regular yields and low labour requirement to meet the continuously rising production costs. A comparison is drawn between the meadow orchard system and the traditional system of fruit growing as given in Table 1.

Table1. Comparison between traditional and meadow orchard systems of guava growing

Attributes	**Traditional system**	**Meadow systems**
Bearing	After two year	From first year
Production	Average yield is 12-20 t ha^{-1}	Average yield 40-60 t ha^{-1}
Management	Difficult to manage due to large trees sizes	Easy to manage due to small tree size
Labour requirement	Require more labour	Require less labour
Production cost	Higher cost of production	Lower cost of production

Harvesting	Difficult	Easy
Quality	Large canopy, poor sunlight penetration and poor quality fruits	Small canopy, better air and sunlight penetration, minimizses disease incidence and high quality fruit with good colour development

Establishing meadow orchard

The meadow orchard system is a new concept of guava planting that has been developed for the first time in India at CISH, Lucknow. In this system, planting is done at 2m (row to row) x 1m (plant to plant), which gives a density of 5000 plants $ha^{-1.}$ Initially, the trees are pruned and trained to allow maximum production of quality fruits during the first year. A single trunk tree with no interfering branches up to 30-40 cm from the ground level is desired to make dwarf tree architecture. After a period of 1-2 months of planting, all the trees are topped at an uniform height of 30-40 cm from the ground level for initiation of new growth below the cut ends. No side shoot or branch should be left after topping. This is done to make a single trunk straight up to 40 cm height. After 15-20 days of topping, new shoots emerge. In general, 3-4 shoots are retained from below the cut point after topping.

As shoots mature generally after a period of 3-4 months, they are reduced by 50 per cent of their total length so that new shoots emerge below the cut point. This is done to attain the desired tree canopy architecture and strong framework. Shoot pruning in high density orchards is prerequisite to maintain the desired canopy of this fast growing guava plant (Lal *et al.*, 2000). The emerged shoots are allowed to grow 3-4 months before they are again pruned by 50 per cent. After pruning new shoots emerge on which flowering takes place.

Under natural conditions, these crops produce flowers thrice in a year i. e. February-March (AmbeBahar), June-July (MrigBahar) and October-November (HasthBahar) with the corresponding harvest during rainy, winter and spring seasons, respectively (Boora *et al.* 2016, Lal *et al.* 2017). The choice of bahar at a particular location is determined by prevailing production constraints like availability of irrigation water, quality of produce, market demand and extent of damage by insect-pests and diseases (Lal *et al.* 2017). The principle behind crop regulation is to induce flowering and fruiting in the desired season of the year that contribute to the increased fruit yield, quality, profitability and sustainability of the environment by reducing the frequency of application of pesticides (Lal *et al.* 2017).

It is emphasized that shoot pruning should be done thrice a year (Singh *et al.*, 1995). This leads to desired canopy development. Though fruiting starts in the same year, one can't expect fruits on each and every shoot. Pruning is continued so that plants remain dwarf. After a year, pruning operation is done especially in April, July and October and height maintenance in month of January- February. The efficient training and pruning can maintain the proper canopy size of

the guava tree, improve fruit quality and provide opportunity to increase the number of trees per unit area (Nautiyal et al., 2016). Nautiyal *et. al., (*2016) had also observed that the interaction between plant spacing and pruning severity had also effect on total annual yield per plant for both the experimental year.

Generally, harvesting of fruits is done in August from the April pruned shoots (first time pruned). After harvest pruning done (second time). After pruning the shoot during July- August, new ones emerge. On these shoots, flowering takes place and fruiting is obtained during October-November. After harvesting pruning done for third time in October and fruiting is obtained in December- January. After that pruning is done for height maintenance of the orchard at 1m ~~m~~ in first year and 1.25m ~~m~~ in second year. This is done primarily for better canopy management. This is the technique for maintain a meadow orchard for optimum production and dwarf tree size. An average production of 4-6kg ~~kg~~ fruits plant^{-1} is obtained every year. As harvesting is easy in a meadow orchard, there is no damage to the fruits (Singh *et al.*, 2000). One guava variety i.e. Pant Prabhat. Is evaluated under meadow orchard system. The positive impact of pruning has been witnessed in this variety.

Fertilization

The amount of manures and fertilizers to be applied in high density /meadow orchard of guava depends on the age of tree, condition of plant and type of soil. Based on the research trials done in Pantnagar for proper growth and higher yield, fertilizer doses should be applied according Table 2.

Table 2: Amount of manures and fertilizers to be applied in high density /meadow orchard of guava

Age of plant (year)	**FYM (kg)**	**N (g)**	**P (g)**	**K (g)**
1	10	75	65	50
2	20	150	130	100
3	30	225	195	150
4	40	300	260	200
5	50	375	325	250
6 and above	60	450	400	300

Use of micronutrients

Guava also shows deficiencies of micro nutrients besides macro nutrients. Boron deficiency shows dark brown color of flesh and severe deficiency leads to hardness of fruits and fruit starts splitting. Spray of Borax @ 0.6-0.8 % twice or thrice can minimize the effect. Borax @ 250 g per plant can be applied in soil in the month of December-January.

It also shows zinc deficiency. Zinc deficiency causes reduced leaf size and fruit number. Spraying of $ZnSO_4$ @ 0.5 % twice or thrice can minimize the effect.

Irrigation

Withholding watering of trees from February to middle of May results in the shedding of flowers and trees go to a rest period during which accumulation of food materials takes place in branches (Sachin *et al.*, 2015).

Weed control

To control weed & unwanted growth in guava high density orchard we can use pre-emergence weedicide/herbicide called Oryzalin .Oryzalin is a weedicide that used for prohibiting the unwanted growth. It is used to control annual grasses, broadleaf weeds, woody shrubs and vines in grapes, berries and many orchard crops, including both fruits and nuts.(1.6 liter/ha),And we also use simazine (1.6 kg/ha) or atrazine (1.6 kg/ha).(Singh,KK.,2018)

Production

In this system, the production starts in the first year itself. In the first year of meadow orchard system, an average of yield 13 tons/ha is approximately obtained which doubles during the next year and will gradually increases year on year. This clearly shows that the meadow orchard system is the most beneficial as compared to others.

Cost of cultivation

The cost of cultivation of guava increased day by day. It depends upon the production. But they vary in different types of states of India and different types of state Agriculture Universities.

The high density or meadow orcharding facilitates enhanced production and quality of fruits. The meadow orchard is a modern method of fruit cultivation using dwarf root stock with modified canopy. Better light distribution within tree canopy increases the number of well illuminated leaves. It also promotes rate of photosynthesis that leads to high yield per unit area. High density planting of guava is going to revolutionize the guava industry by enhancing productivity coupled with reduction in production costs. The meadow orchard system of guava accommodates 5000 plants/ ha, planted at 2.0m x 1.0 m spacing and managed with regular topping and hedging, especially during initial stages. Topping and hedging in guava are helpful in controlling tree size and extending fruit availability (Singh, 2010).

Shoot pruning is also helpful in reducing the tree size and improving the fruit quality and provide opportunity to increase the number of trees per unit area (Lal *et al*., 2000). Kundu (2007)

reported that high density planting in guava may be adopted as it increased the yield significantly per unit area with insignificant or less reduction in fruit weight and quality. The fruit diameter significantly increased with the decreasing plant population per unit area (Pal *et. al.,* 2017). Maximum plant height and highest yield per hectare was recorded in double hedgerow system of planting. (Lal *et al*., 2007). Work done by Singh (2010) at CISH Lucknow on meadow orchard of guava revealed that apical growth controlled within the first year of planting for better architecture by topping to a uniform height of 60-70 cm from the ground level and further 50 per cent new emerged shoot were pruned for enhanced production.

Singh *et al.* (2007) observed in high density of guava that after harvesting, trees pruned and headed back small branches to a length of 50 cm favoured horizontal shoots and maintained tree dwarfness without excessive growth. Experiment on guava conducted by Singh (2010) revealed that new emerged shoots of guava reduced by 50 per cent of their total length so that new shoots emerge below the cut point. The emerged shoots were allowed to grow for 3-4 months before they were again pruned by 50 per cent. Regular pruning of guava was done for maintaining meadow orchard for optimum production and dwarf size (Singh *et al.,* 2000). Gaur (1996) reported that pruning the top half of the current season's growth of Allahabad Safeda guava improved the fruit size during both rainy and winter season crop. The maximum number of flower buds per branch, the maximum fruit-set percentage and the minimum per cent flower bud abscission were found with one leaf pair pruning treatment for winter season crop (Tiwar and Lal, 2007). Dalal*et al*. (2000) studied the effect of severity of pruning on growth and quality of fruits of 25 year old guava tree cv. Sardar and they found that pruning increased fruit yield per tree.

Lal *et al.* (2000) study the effect of plant spacing and pruning intensity on fruit yield and quality of guava and found that winter season crop was maximum with one leaf pair shoot pruning. Thakre *et al.* (2013) observed that the maximum number of fruits and total yield for winter season were recorded with the one leaf pair pruning, while minimum in control. During rainy season, the reverse trends were observed. Pratibha *et al.* (2013) concluded that one leaf pair pruning in guava cv. Sardar planted under square system was useful to maximize yield in winter season crop under *terai* regions. Joshi *et al.* (2014) reported that the maximum fruit yield per hectare during winter season can be obtained at 2.0m X 1.0 m plant spacing with three fourth ($3/4^{th}$) shoot pruning during last week of April. It was also observed that the reducing sugar percentage of fruits increased with wider spacing which might be due to lesser competition among plants for nutrients and better penetration of sunshine for photosynthesis. (Joshi *et al* 2016, Pal *et. al.,* 2017). Joshi *et al*. (2016) concluded that physico-chemical qualities of the guava fruits were found superior at 2m x 2m ~~meter~~ spacing.

Singh *et al.* (2000) reported that from economic point of view, it is desirable to take a sole winter crop instead of three crop in a year. Tiwari and Lal (2007) reported that on the basis of yield and net returns during both the seasons, for regulating the cropping pattern in guava and obtaining maximum winter season yield of superior quality fruits, one leaf pair shoot pruning

should be done in the first week of May. Nautiyal *et. al.,* (2016) observed that as pruning severity increased, there was a reduction in fruit set and increased the flower/ fruit drop percentage for rainy season crop which ultimately increased the fruit set for winter season crop. Nautiyal *et al.* (2020) observed that plant growth fruit yield and profitability of guava can be influenced by pruning severity. Fruit yield per hectare increased with increase in plant population per unit area. The maximum benefit: cost ratio was found with the treatment complete removal of non-fruiting shoots followed by one leaf pair shoot pruning due to high winter season fruiting.

Conclusion

Certain important strategies have been identified for enhancing guava production in India in order to be competitive in the national and international markets. They involve adoption of modern, innovative and hi-tech methods. One such strategy is the high density plantation (HDP) and meadow orcharding. This includes adoption of appropriate plant density, canopy management, quality planting material, support and management system with appropriate inputs. In view of the popularity of these technologies and subsequent benefits, it is now high time to encourage the adoption of these technologies by the guava growers.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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