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Doubling the guava farming based farmer's income through enhancing productivity using Hi-tech practices

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Abstract
The Enhancement farmers income is formulated by bridging the productivity gaps, employing latest production technologies, advanced cropping technologies and improved marketing and feasible through efficient land use planning, wasteland management, diversified farming systems, climate resilient horticulture, precision farming, dry land farming, protected cultivation, modern nursery management techniques for improvement in horticulture productivity, resource use efficiency, increase in cropping intensity and diversification towards high value crops. There is necessary a shift in farmers‟ insight from production to productivity and profitability which can be achieved through high density planting with effective implementation of high tech practices in guava. Central Institute of Sub tropical Horticulture (CISH), Lucknow proved that guava can be successfully grown at closer spacing under high density planting to meadow orchard system with spacing of 2 m x 1m accommodating 5000 plants / hectare. Average yield obtained in meadow orchard system of guava growing is 40 – 60 t /ha when compare to traditional system. Meadow systems in guava had more advancement in improvement in terms of early fruit bearing in first year, Easy to manage due to small trees, Increased overall production (30-50 t ha-1), Reduced cost of production, labor cost and it is very easy to harvesting due to small canopy encourages air to circulate and sunlight to penetrate into center of the tree canopy, good air circulation over traditional systems. Studies indicated that pruning of guava trees can enhance the productivity under high planting density. Pruning restores balance between shoot and root system, besides maintains the growth and vigour of shoots by allowing fewer growing points to grow vigorously. It is important to adopt canopy management and crop regulation practices viz. pruning, withholding of irrigation water, root exposure and root pruning, shoot pruning, shoot bending, deblossoming practices and using saline tolerant rootstock etc. Even though number of plants with well-developed frame work is maintained, the plants may starve for nutrients due to competition. This can be overcome by following the nutrient recommendation standardized for particular planting density. Fertigation and micronutrient application are the major practices in guava to obtain higher yields. The method of application of all essential inputs viz. growth regulators, and micro nutrients for plant growth also had influence on crop growth, productivity and ultimately enhances farmers income.

Keywords: meadow systems, crop regulation, pruning, guava, enhancing farmers' income

1. Introduction
Guava (*Psidium guajava* L. family: Myrtaceae), ‘‘Poor man’s fruit’’ or ‘‘Apple of tropics’’, is an important fruit crop of tropical and sub-tropical regions of India. It has gained considerable prominence on account of its high nutritive value, pleasant aroma, good flavour and availability at affordable price. It is the fifth most widely grown fruit crop of India and grown in an area of about 2. 85 million hectares, with a production of 3. 72 MT annually (NHB, 2020-21). Major guava producing states of India are Madhya Pradesh, Maharashtra, Uttar Pradesh, Bihar, West Bengal, Andhra Pradesh, Punjab, Gujarat, Chhattisgarh and Karnataka. It is an excellent source of vitamin-C, pectin and minerals. In general, fruits with red peel and pulp are an excellent source of antioxidants. It is also a very hardy fruit crop which can be grown on a wide range of edaphic and climatic conditions.
Previous strategy for development of the agriculture sector in India focused primarily on raising agricultural output and improving food security. This strategy did not explicitly recognize the need to raise farmers’ income and did not mention any direct measure to income of the cultivators remained low still after the 70years of independence which is evident from the incidence of poverty among farm households. Realizing the need to pay special attention for the welfare of farmers and to reduce agrarian distress set a goal the country will complete 75 years of its independence.

High cost of input in horticulture crops, prevalence of old and senile orchards, unorganized supply chain are the major bottle neck, therefore, adoption of organic agriculture practices and farming system approach should be promoted for decreasing input cost and ultimately increasing the income. Moreover, rejuvenation of old and unproductive orchards and organized marketing are also very important for getting remunerative income. However, cluster based approach linked with postharvest management and marketing, market intelligence to promote market led production, quality seeds and planting material, adoption of improved varieties and rejuvenation with improved cultivars, hi-tech horticulture and precision farming, high density plantations, etc. could be utilized to double the farmer's income in horticulture crops.

Guava is considered to be the fourth mostimportant fruit after mango, banana and Citrus in India. t is considered to be more remunerative crop to the farmers due to its high productivity, easier cultivation and less cultivation cost. In the recent past, it has gained momentum owing to its versatility in adaptability to a wide range of soil conditions, especially problem soils such as saline, alkaline and even in clayey soils too. It is available at reasonable price and known for its rich nutraceutical values (Kumar and Mishra, 2012) [16] thus, named as apple of tropics and super fruit (Maji *et al.* 2015) [20]. Amongst various tropical fruit crops in India, guava, if left on its own, give the variable quantities and qualities from the various flowering flushes throughout the year. In general, guava flowers twice in a year i. e. in March-April (Ambebahar) and June-July (Mrigbahar), of which fruits ripen in rainy and winter season, respectively. However, in central and Southern part of India, there is a third crop with flowers appearing in October (Hasthabahar), of which fruits ripen in the month of March was also realised. This pattern of flowering and fruiting is not desirable for commercial exploitation. Moreover, the fruits of Ambebahar which are harvested during the months of JulySeptember and insipid, watery, and poor in quality and heavily infested with fruit fly resulting in significant loss to most of the guava growers (Mishra and Tiwari, 2000) [23]. The winter season fruits are superior in quality, free from pests which fetch high monetary returns (Singh *et al.* 2000) [43]. Many works have been carried out for improving the yield and fruit quality of guava in India through various technologies (Boora *et al*. 2016, Lal *et al.* 2017, Hojo *et al*. 2007, Khan *et al.* 2011, Mamum *et al.* 2012, Atawia*et al.* 2017) [6, 18, 11, 13, 21, 2]. Hence, it is highly essential to implement certain important modern, innovative and hi-tech methods for improving the quality as well as quantity of guava production.

2. High density planting

There is a shift in farmers‟ insight from production to productivity and profitability which can be achieved through high density planting. High density planting has been in practice as a prime method for improving productivity of temperate fruit crops like Apple. In the past one decade, strenuous efforts were made to adopt high density planting in tropical fruit crops also. Presently, the trials on mango and guava HDP are practiced as successful technologies. Recently trials from Central Institute of Sub tropical Horticulture (CISH), Lucknow proved that guava can be successfully grown at closer spacing under high density planting to meadow orchard system with spacing of 2 m x 1m accommodating 5000 plants / hectare. By judicious canopy management and suitable tree training systems higher and quality production is achieved from densely planted orchards by regular topping and hedging especially during early stages. Average yield obtained in meadow orchard system of guava growing is 40 – 60 t /ha when compare to traditional system (Singh, 2008) [40].

Guava layers of variety Lucknow- 49, was established well at a spacing of (3 x 1. 5 m) accommodating 2222 plants/ hectare under sodic- alkaline soil conditions with the ESP of above 15% at HC & RI (W), TNAU, Trichy, Tamil Nadu (Auxcilia *et al.* 2019) [3]. These studies indicated that though the yield of individual plant is less under HDP, compared to moderate density or low density, owing to the increased number of plants per hectare, the total yield realized from an hectare is doubled or tripled and thus profitable to farmers.

Apart from high density planting, moderate density levels were also found to increase the productivity of guava at certain places. According to Brar *et al.* (2009) [7] fruit yield was increased significantly with decrease in density of plants during both the crop seasons. In rainy season, the yield per tree was significantly affected by plant spacing. At widest spacing of 6×5 m, highest yield of 35. 15 kg/plant was obtained, followed by 6 ×4 m spacing, which gave a yield of 25. 87 kg/plant and 6 × 2 m spacing gave the least yield of only 15. 07 kg/plant. A highest yield of 17. 25 kg/plant at 6 ×5 m spacing and minimum yield of 6. 83 kg/plant at 6 x 2 m spacing was recorded during winter season. Similar results were reported by Lal *et al.* (2000) [17, 19]. and It was concluded that a spacing of 6 x 4 m with 416 plants/ha exhibited optimum microclimatic conditions in the canopies of plants and also accommodated 20% more plants when compared to the present recommendation of plant density without affecting the fruit yield and quality (Bal and Dhaliwal, 2003) [4].

Comparison between traditional systems and HDP systems of guava growing

Attributes	Traditional systems	Meadow systems
Bearing	After two years	From first year
Production	Overall production is low (12-20 t ha-1)	Increased overall production (30-50 t ha-1)
Management	Difficult to manage due to large size of trees	Easy to manage due to small trees
Labor requirement	More	Minimum
Production cost	Higher cost of production	Reduced cost of production
Harvesting	Difficult	Easy
Quality	Large canopy, poor sunlight penetration and poor quality	Small canopy encourages air to circulate and sunlight to penetrate into centre of the tree canopy, good air circulation minimizes disease, sunlight interception contributes to high fruit quality and colour

(Singh *et al*. 2012)

3. Canopy management practices using Hi-tech practices

Training and pruning practices are integral part of high density planting systems. High density planting obviously needs to be combined with training and pruning techniques. Studies indicated that pruning of guava trees can enhance the productivity under high planting density. Guava respondswell

to pruning, because it bears fruits on current season growth and flowers appear in leaf axils. Pruning restores balance between shoot and root system, besides maintains the growth and vigour of shoots by allowing fewer growing points to grow vigorously.

3.1 Flower induction

Flower production is bound to increase due to pruning, as pointed out by several studies. Singh *et al*. (2001) [42] studied the effect of pruning dates on yield of guava cultivars Allahabad Safeda and Sardar for five consecutive years. They reported that pruning rom April to June, enhanced the flowering percentage as compared to pruning in February and March. Jadhav *et al.* (2002) [12] noticed that the number of flowers per shoot on severely pruned (60%) trees of guava were more when compared to mild pruned (30%) trees and control. Mohammed *et al.* (2006) [24] noticed that maximum flowers per shoot during winter season were in 60 cm pruning treatment. Mehta *et al*. (2012) [22] conducted an experiment to study the effect of pruning on guava cv. Sardar under ultra-high-density orchard system. Pruning thrice a year produced maximum number of flowers per plant (20. 13), while pruning of 80% of canopy in October produced minimum number of flowers per plant (7. 72) during winter season of 2009-10. To study the effect of pruning and planting systems on growth, flowering, fruiting and yield of guava cv. Sardar an experiment was conducted by Kumar and Rattanpal (2010) [14]. The results revealed that pruning the 1/2ndof vegetative growth in 6m x 4m spacing recorded the highest yield of 544 number of fruits / tree and 55. 1 kg /tree. The estimated yield was 54. 4 t/ha.

3.2 Crop regulation

Amongst various tropical fruit crops in India, guava, if left on its own, give the variable quantities and qualities from the various flowering flushes throughout the year. Under natural conditions, these crops produce flowers thrice in a year i. e. February-March (AmbeBahar), June-July (Mrig Bahar) and October-November (HasthBahar) with the corresponding harvest during rainy, winter and spring seasons, respectively (Boora *et al*. 2016, Lal *et al.* 2017) [6, 18]. However, the responses differed according to cultivars, tree conditions, soil types and agroclimatic conditions (Maji *et al.* 2015) [20]. Regulated crops are desired to avoid glut in the market and also ensure the regular supply of fruits. 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) [18]. The principle behind crop regulation is to induce flowering and fruiting in desired season of the year that contribute to increased fruit yield, quality, profitability and sustainability of the environment by reducing the use of the frequency of the pesticides (Lal *et al.* 2017) [18].

3.3 Withholding of irrigation water

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) [31]. But not sandy in heavysoils (Tiwari and Lal, 2000) [50].

3.4 Root exposure and root pruning

Carefully, 7-10cm upper soil around the tree trunk in a radius of 40-60 cm are removed so that roots are exposed to the sun which results in reduced moisture supply to the top, therefore, the leaves begin to shed the leaves and tree goes to a rest period. After above 3-4 weeks, the exposed roots again covered with soil and manure mixture followed by watering (Lal *et al*. 2017) [18] to get a good crop (Sachin *et al*. 2015, Suresh *et al*. 2016) [31, 46].

3.5 Shoot pruning

Guava flowers are always borne on newly emerging vegetative shoots; irrespective of the time of years, shoot pruning have been reported to be successful. Shoot pruning ishelpful in reducing the tree size and improving the fruit quality Singh and Bal, 2006, Lal *et al.* 2000 [17, 19], Dhaliwal and Singh, 2004 [9], Kumar and Mishra, 2010 [15], Tiwari and Lal, 2007 [51], Sharma *et al.* 2013 [38], Prakash *et al.* 2012 [27], Thakre *et al.* 2013 [48], Pratibha and Lal, 2013 [28], Thakre *et al.* 2016 [49], Joshi *et al.* 2016, Salah, 2005 [33]. The time and intensity of pruning affected tree sprout and yield guava cv. Paluma (Sarrano *et al.* 2008a, Sarrano *et al.* 2008b) [36, 37], in Nepal (Adhikari and Kandel, 2015) [1], in Cairo, Egypt (Sahar and Hameed, 2014) [32].

3.6 De-blossoming

De-blossoming of rainy season crop subsequently increased the winter season crop (Singh *et al*. 2016, Lal *et al.* 2017) [45, 18]. Manual deblossoming on a commercial scale is economically not viable (Singh *et al*. 2002) [41]. In contrast to this Das *et al.* (2007) [8] found it economically profitable when 50% of rainy season crop is removed manually. Deblossoming with 100 ppm NAA (Das *et al*. 2007) [8] and 200ppm NAA (More *et al.* 2016) [25] were effective for guava cv. L-49 inrainfed plateau conditions in Eastern India. Flower thinning by Naphthalene Acetamide (NAD) (Maji *et al.* 2015) [20], 2, 4-D (Das *et al.* 2007) [8], Potassium Iodide (Sachin *et al.* 2015) [31] and ethephon (Singh *et al.* 2000) [43]. Urea spray was also found efficient for deblossoming (Singh *et al.* 2002) [41].

3.7 Branch bending / Shoot Bending & Fruit Thinning

Breaking the apical dominance and activating the latent buds present on the branch (Samant *et al.* 2016) produce better quality fruits in the offseason (Sarkar *et al.* 2005, Mamun *et al.* 2012) [35, 21] and maintaining increased C:N ratio and induce more flowering and fruit set (Mamun *et al.* 2012) [21]. Mamum *et al.* (2012) [21] studied the combined effect of variety and different management practices on fruit yield (kg/plant) and found that was significant both in on-season and offseason (Table 1). The highest fruit yield of 23. 15 kg/plant was obtained in the variety Chiang Mai (round) in the treatment combination of 50% fruit thinning with bending during on-season. In variety Swarupkathi the same combination treatment recorded a yield of 16. 06 kg/plant.

3.8 Root stock

Collection and evaluation of guava germplasm for physiological and biochemical basis for sodicity tolerance studies were carried out at Horticultural College and Research Institute for Women, Trichy during 2014 to 2019. 34 different accessions of guava were collected and evaluated for yield and physiological and biochemical parameters under saline-sodic condition. The maximum physiological activity and leaf K/Na ratio was recorded inMirzapur Seedling (20. 155) ollowed byKarela (18. 928) and minimum recorded in

Seedless (1. 604). The maximum leaf K/Ca+Mg ratio was recorded in Cheeni guava (0. 156) followed by Mirzapur Seedling (0. 134) and minimum recorded in Lucknow 46 (0. 008). Mirzapur Seedling, Cheeni guava and Karela could be used as rootstock under saline condition (Santhi *et al*. 2019) [30] which increases the area and productivity of guava in India.

4. Conclusion

It is concluded that the above-mentioned novel techniques for guava is scientifically proven that are highly potential enough to improve the crop productivity. The ultimateaim is to increase the productivity per unit area with the effective utilization of optimum inputs. All these studies showed that productivity can be increased by increasing the population per unit area. It is certain that the increased population will not alone perform well unless their stature maintained according to the space allotted to each of them. Hence, it is important to adopt canopy management and crop regulation practices viz. pruning, withholding of irrigation water, root exposure and root pruning, shoot pruning, shoot bending, deblossoming practices and using saline tolerant rootstock etc. Even though number of plants with well developed frame work is maintained, the plants may starve for nutrients due to competition. This can be overcome by following the nutrient recommendation standardized for particular planting density. Fertigation and micronutrient application are the major practices in guava to obtain higher yields. The method of application of all essential inputs viz. growth regulators, and micro nutrients for plant growth also had influence on crop growth and productivity. For instance, using drip system for irrigation and fertigation ensure effective uptake of water and nutrients by the plants. Hence it is clear that the technologies capable of improving plant growth via different cultural practices have to be utilized in an integrated manner for getting remarkable results. So, it is our duty to popularize and handover the setechniques to farmers so that our ultimate goal can be achieved practically.

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