The Pharma Innovation Journal 2022; SP-11(1): 471-475

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(1): 471-475

www.thepharmajournal.com
Received: 07-11-2021
Accepted: 09-12-2021

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Effect of branch level and leaf pruning in vegetative growth, yield and quality of guava: A review

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Abstract
Pruning is a technique in which undesirable parts of a plant are removed judiciously to achieve the desired purpose. It is practiced on shoots, leaves, as well as on roots. Guava comes under the category of crops that bear on current season shoots; hence responds well to pruning. The major purpose of pruning in guava is to reduce the fruit set during the rainy season, which is of inferior quality to enhance the production during the winter season. The Winter season crop in guava is superior in terms of fruit size, quality, shelf life, and organoleptic values. Pruning also helps in the transformation of unproductive trees into productive ones, especially in guava plantations. Pruning at different intensities done at particular timings has shown different effects on the vegetative growth, flowering, yield, as well as quality parameters of the crop. The pruning requirement in fruit plants is crop-specific, and it depends on growth behavior, therefore, standardization of pruning is essential for improving these parameters under given environmental conditions. Moreover, the adoption of judicious pruning intensities and timings can augment the production of high-density planting in guava. Therefore, different techniques of pruning have involved the attention of many researchers to find some optimistic approaches. In this review, we have tried to compile the previous research findings in a precise way to address the problem.

Keywords: branch level, guava, growth, and quality, leaf pruning, yield

Introduction
Guava (*Psidium guajava* L.) commonly known as 'Apple of Tropics' is successfully cultivated over different sets of climatic conditions due to its wide range of adaptability. In India, it is being cultivated in an area of 2.76 lakh hectares with an annual production of 42.53 lakh tonnes and a productivity of 15.3 MT/ha (Anonymous, 2020). The leading guava-producing states in the country are Uttar Pradesh, Bihar, Madhya Pradesh, and Maharashtra. The farmer is attracted to guava cultivation due to its lower cost of production compared to other fruit crops, moreover, its cultivation gives assured returns with little care. Due to its good nutritive value and easy availability at moderate prices, it has gained considerable fame among the consumers. It is a wholesome fruit and a rich source of ascorbic acid, pectin, dietary fiber, and minerals. It flowers thrice in a year *viz*, spring (ambe bahar), rainy (mrig bahar), and autumn (hasta bahar). The highest flowering intensity is observed during rainy season cropping because of abundant humidity and the emergence of current shoots which bear flowers in leaf axils and ultimately produce fruit. But, fruits of the rainy season are poor in quality and are vulnerable to the attack of pests like fruit fly. On the other hand, fruits in the winter season are of superior quality, which in turn lead to better demand and higher prices in the market than the rainy season crop. Consequently, the winter crop production must be enhanced by suppressing the rainy crop by adopting different techniques of pruning.

In addition, after 8-10 years, the guava tree shows a significant decline in the yield due to dynamic vegetative growth and overcrowding of branches. At this stage, pruning practices are advised to adopt for improving production, as pruning reduces vegetative growth and leads to the formation of new buds/shoots, thereby more fruits. Fruiting also can be improved by light penetration, photosynthesis, and water and nutrient uptake (Bhagawati *et al*. 2015) [6]. Pruning technology has a positive effect in improving fruit crops in terms of yield and quality (Sahar *et al*. 2014; Hamdy 2016; Schupp *et al*. 2017; Suresh *et al*., 2017, Kadam *et al*. 2018) [38, 41, 47, 14, 17] also reported that maximum sugar content can be obtained by pruning at 15 cm, whereas maximum TSS could be obtained by 20cm pruning in custard apple. However, Balamohan *et al*. (2019) [5] found that a combination of light pruning and paclobutrazol significantly improved fruit length, weight and pulp weight in guava under the HDP system. Sharma *et al*. (2019) [42] also reported that in guava TSS and vitamin C are better in heavily pruned trees.

Likewise, Singh *et al*. (2021) [44] opined that pruning guava at 60% intensity during early June along with bagging of 20 days old fruits results in better yield. Similarly, Paikra *et al*. (2021) [31] reported that pruning is helpful in the production of better-quality fruits. Kumar *et al*. (2010) [23] experimented to find out the effect of severity of pruning on plant height and observed maximum plant height with control treatment and minimum with 50% pruning. Sah *et al*. (2017) [37] reported maximum plant height when pruning was done in April. An experiment conducted by Saini *et al*. (2011) [39] advocated that removal of current season growth up to 45cm resulted in a maximum number of sprouts. But Shinde *et al*. (2000) [43] observed the highest number of shoots per tree when pruning was done only 20 cm in guava cv. Sardar. Overall, pruning restores the balance between shoot and root system which upholds the growth as well as vigour of shoots by allowing only a few growing points to grow dynamically.

Effect of branch pruning level/intensity on vegetative growth

Lakpathi *et al*. (2013) [24] experimented with different intensities of pruning (removal of shoot up to 10 cm, 20 cm, and 30 cm from the base) along with retention of 30, 40, and 50 fruits/ tree. They found that pruning of shoot up to 10 cm resulted in an optimal balance between vegetative and reproductive developments of the guava plant. Whereas, Kovaleski *et al*. (2015) [21] revealed that high levels (removal of 60% of canopy) of pruning increased the number of lateral branches, which may change hormonal activities in blueberries. He also determined that apical meristem, as a resource sink, plays a significant role in shifting basal meristem towards new shoots, floral growth, and development processes. Mahesh *et al*. (2016) [26] opined that pruning at an intensity of 25% initiated towards the end of summer resulted in profuse growth as the trees were receiving adequate periods of rest followed by pruning and irrigation. Their findings were supported by Kamal *et al*. (2016) [18] who stated that an increase in canopy spread might be the result of an increase in shoot length, as it is the principal factor causing canopy spread. Kamal *et al*. (2016) [18] recorded maximum shoot length (24.32 cm) in May pruned plants in guava cv. Lalit. Nafisah *et al*. (2019) [29] conducted a study on crystal cultivar of guava and revealed that the number of flowers produced, is highest in the case of 30 cm pruning and thereafter the number decreased. In coffee pruning technique has facilitated vertical growing tendency, thereby allowing the high-density planting system in coffee without a negative effect on yield (Gokavi *et al*. 2021) [12]. Rani *et al*. (2021) [35] have experimented litchi and reported that working with physiology and time of flush maturity affects the vegetative and floral characteristics of the fruit.

Effect of branch pruning level/intensity on yield

Mehta *et al*. (2012) [28] experimented with an ultra-high-density orchard of guava cv. Sardar and recorded the maximum yield of summer season crop with 50% shoot pruning in three times a year (March, May, and October). However, the maximum yield of the rainy crop was recorded with 80% pruning of canopy in October, and in the case of winter crop pruning up to 60% of canopy brought maximum yield. Joshi *et al*. (2014) [16] noticed the maximum yield of winter crop with May pruning, as it induced flowering in August which led to better winter crops. The maximum fruit yield of 37.9 kg/tree in the rainy and 52.3 kg/tree in the winter season crop, was obtained by 10 cm pruning level in guava cv. Sardar. Sousa *et al*. (2015) [46] opined that along with planting density and training techniques, pruning also influences the yield of the fruits. Adhikari *et al*. (2015) [2] also found similar results in guava cv. L-49 and recognized maximum fruit yield in winter with mild pruning (20 cm) and noticed that yield of the rainy crop decreased with delay in pruning. However, the maximum yield of the winter crop was obtained by pruning in early May. Whereas, Bhagawati *et al*. (2015) [6] reported that severe pruning leads to both increase in yield per tree (11.66 kg/tree) and per ha (18.16 t/ha) compared to lesser intensities of pruning and control treatment (5.98 kg/ tree and 9.01 kg/ ha) in guava. Similarly, Agnihotri *et al*. (2016) [3] reported that pruning (50% intensity) produced the highest (42.50 kg/tree) fruit yield compared with fruit yield obtained by 75% intensity (36.88 kg/tree) in 2-year-old meadow orchards of guava cv. Lalit. However, Meghwal *et al*. (2017) [27] considered moderate pruning as the best option for obtaining a maximum yield of quality fruits and they also suggested that in rainfed areas light pruning should be followed to obtain a higher yield in ber. Camus *et al*. (2018) [7] reported that in guava 25% pruning intensity exhibited a positive impact on fruit yield, while 50% intensity had given a better impact on both aspects of fruit yield and quality. Desai *et al*. (2018) [9] reported in sapota and jatropha that a 50% level of pruning leads to improved results concerning yield characteristics. Widyastuti *et al*. (2019) [51] experimented crystal guava, (a popular cultivar of guava, in Indonesia) from March to October, and suggested that pruning accelerates the time required for flowering, the emergence of new shoots, and the number of flowers per tree, and all these events finally lead to higher fruit yield. Shinde *et al*. (2000) [43] observed the highest yield in 10-year-old guava cv. Sardar with 20 cm pruning as compared to other intensities of pruning (0,5,10,15,20,25 and 30 cm). Kumar *et al*. (2021) [22] reported that pruning has regulated both vegetative growth and flowering, which in turn regulated the flowering and fruiting resulting in a better yield of pomegranate.

Effect of branch pruning level/ intensity on Quality Characters of fruit

Singh *et al*. (2010) [45] revealed that among different intensities of pruning (control, light, moderate and severe pruning) severe pruning resulted in the highest TSS. They revealed that the total sugars of the fruit were not influenced by pruning intensities in the case of mango. Similarly, Rawat *et al*. (2010) [36] concluded that ascorbic acid, sugar-acid ratio, pulp weight, stone weight, pulp-stone ratio, and moisture content were unchanged by pruning intensities, whereas, fruit weight, size, TSS, sugar, and acid content were suggestively augmented by pruning intensities in Flordasun peach. Kumar *et al*. (2010) [23] reported that shoot pruning improves the quality of fruit and it significantly increases productivity. They observed that vitamin-C and TSS in guava fruit increased by the pruning intensity level in guava. Ram *et al*. (2011) [34] opined that physio-chemical characters of ber like, fruit weight, length, acidity was greatly affected by pruning levels. They also reported that acidity was higher in light pruning than in medium. Whereas, Fischer *et al*. (2012) [11] recorded that partial removal of some leaves and remaining the available leaf may support growing/developing fruits by supplying more photosynthate materials to them, resulting in improvement of TSS but decreasing the acidity. Uddin *et al*. (2014) [50] reported in mango that severe pruning (30 cm down

from the apex) gave a better result in the improvement of traits of the fruit (like size, weight, color). Gopu *et al*. (2014) accessed maximum acidity in a high level of pruning in mango. They found that light pruning gives better results in the improvement of physical characteristics of the fruit like size, length, etc. They concluded that acidity and ascorbic acid exhibited improved results in light pruning practice. It was also submitted that competition for light resulted in more acidity in unpruned plants in guava. Samant *et al*. (2016) [40] reported that in HDP guava orchard, 70% level of pruning showed a positive influence on TSS and vitamin-C under Odisha climate. Likewise, Hamdy (2016) [14] also described that light and moderate pruning gave desirable results in respect of yield and positive impact on TSS and TSS: Acid ratio in Fremont and Murcott cultivars of mandarin.

Effect of leaf pruning level/ intensity on Vegetative growth

Petrie *et al*. (2000) [33] subjected grapevines to different levels of leaf pruning (retention of 100%, 66%, 33%, and 0% leaves) and opined that leaf removal improved photosynthesis rate by increasing chlorophyll and stomatal conductance. Adams *et al*. (2002) [1] had advocated that leaf pruning can enhance strength, growth rate, productivity, and quality of fruits in tomato cultivation. Leaf pruning does not affect the cumulative yield. Similarly, Hachmann *et al*. (2014) [13] opined that leaf removal not only improves the aeration and solar radiation but also decreases pests in tomatoes. Likewise, Feng *et al*. (2015) [10] documented in grapes that various diseases may be limited by leaf pruning. Moreover, the removal of leaves significantly improved the light intensity and air circulation. Intrieri *et al*. (2016) [15] concluded that grape leaf pruning had a significant effect on reducing different diseases but it also lowers the fruit set. They also opined that that leaf pruning had some impact on fruit morphology, especially on reducing fruit compactness. Similarly, Thakre *et al*. (2016) [48] conducted an experiment on guava cv. Pant Prabhat under high-density planting (HDP) to identify the effect of leaf pruning in growth, yield and quality parameters and reported maximum (98.31) new shoot emergence per branch with the treatment RLF (Removal of all leaves and flower buds by hand) and minimum (33.72) was recorded with control treatment in winter season crop. As far as the annual increase in tree height was concerned, a maximum (0.475 m) was recorded with the severe form of pruning (FSP-Full shoot pruning) while the minimum was recorded with OLPS and OLPF treatments. The maximum annual increase in the crown spread (1.363 m) was recorded with RLF and the minimum (1.022 m) was recorded with FBTT (Flower bud thinning by hand followed by removal of terminal one leaf pair) treatment.

Effect of leaf pruning level/ intensity on Yield and Quality Characters of fruit

Tiwari *et al*. (2007) [49] described that maximum return/revenue can be obtained by pruning one leaf pair shoot in guava, as it leads to maximum yield (88 kg/tree) with good quality fruit production during the winter season. Pastore *et al*. (2013) [32] noted that grapevine pre-flowering leaf pruning showed a positive impact on fruit quality regarding sugar. It was also reported that defoliation before blooming decreases yield and delays the fruit ripening process. da Silva *et al*. (2011) [8] suggested that, as tomatoes are very susceptible to many diseases, it is necessary to reduce the incidence of disease by removal of leaves from the basal parts of the plant to enhance the yield. Kotseridis *et al*. (2012) [20] conducted a study in four grape cultivars namely; Merlot, Cabernet, Sauvignon, and Sangiovese and observed that leaf pruning resulted in lower yield and cluster weight in Merlot and Sangiovese and decreased yield per vine and cluster weight in Merlot and Sangiovese, whereas, yield remained unaffected by leaf pruning in Cabernet Sauvignon. Balamohan *et al*. (2019) [5] found that a combination of light pruning and paclobutrazol significantly improved fruit length, weight, and pulp weight in guava under the HDP system. Sharma *et al*. (2019) [42] also reported that in guava TSS and vitamin C are better in heavily pruned trees. Leaf pruning in tomatoes has exhibited positive effects in terms of yield and quality under greenhouse conditions (Kim *et al*. 2014) [19]. Lyu *et al*., 2014 [25] enlightened that in strawberry defoliation practice and yield was opposite to each other i.e., increased leaf pruning leads to decline fruit set. Ntamwira *et al*. (2014) [30] found that the average yield of bananas with seven leaves at Bur hale, south Kivu province was higher than the control treatment. Whereas, Thakre *et al*. (2016) [48] noted maximum yield in case of control treatment, followed by OLPS (One leaf pair shoot pruning) and OLPF (One leaf pair pruning of fruit shoots only) treatments during the winter season and they also concluded that all the treatments meaningfully reduced the yield per tree for rainy season crop.

Conclusion

By reviewing several research and review papers especially in guava, it can be concluded that through branch level and leaf pruning, various vegetative, yield, and quality parameters of the crop can be improved. As the pruning requirement in fruit plants is crop-specific, and it depends on growth behavior, standardization of pruning is essential for improving these parameters under given environmental conditions. Therefore, systematic research studies concerning pruning time and specific pruning techniques should be carried out under different climatic zones.

Future guidelines

The impact of different chemicals along with different pruning techniques on tree growth, flowering, and fruit set development and quality should be studied. This technique will definitely help to generate a proper strategy required for substantial food production.

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