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Research Article

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Impact of Pruning Levels and Tree Age on the Productivity and Fruit Quality in Guava CV. Allahabad Safeda

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Abstract

The guava (*Psidium guajava* L.) is an evergreen fruit species that flourishes in diverse soil types and climates. The long-term productivity and sustainability of guava trees hinge on maintaining a harmonious balance between their vegetative and reproductive phases. Therefore, ensuring adequate nutrient supply and effective canopy management becomes crucial. This study aimed to explore the impact of varying pruning techniques and the age of guava trees (cv. Allahabad Safeda) over two years. Pruning resulted in maximum average length of shoot (11.34 cm), number of flowers per shoot (5.65), fruit set (82.27%), yield (28.57 kg), fruit weight (127.24 gm), Total Soluble Solids (TSS) (10.05 °Brix), total sugar (6.56) and ascorbic acid (168.48 mg) whereas opposite trend in acidity, initiation of flowering (65.55 days) and flower bud emergence to anthesis (35.00 days) was observed. Intensifying the degree of pruning leads to the highest possible improvement in all parameters including the yield of guava trees. In both years of the study, pruning and age of plants significantly increased the amount of harvestable fruit. The pruning level of 20 cm was reported to be the most effective pruning for higher productivity and better fruit quality in guava. Further, the trees with relatively greater age (11 years old or more) can respond effectively to pruning.

Keywords

Psidium guajava, Pruning level, Plant age, Fruit quality

Introduction

Fruit crops offer a promising solution for diversifying Indian agriculture and boosting profits. By engaging in horticulture activities, farmers can increase land productivity, create employment opportunities, improve their economic conditions, and enhance nutritional security. The production of high-quality fruit crops led to increased foreign exchange earnings and attracted a new generation of entrepreneurs to the industry. Beyond their economic advantages, fruit crops play a vital role in preserving biodiversity, upholding ecological equilibrium, and fostering sustainable agricultural practices [1].

Guava (*P. guajava* L.) is often called the "apple of the tropics”. This tree exhibits a distinct flowering cycle. In southern and western India, it blooms three times yearly-specifically, in February, June-July, and October. Conversely, North India experiences two flowering phases annually: April-May for the rainy season crop and August-September for the winter season crop [2]. Guava trees depend on light absorption for growth, fruit yield, and quality. Leaves in deep shade areas do not photosynthesize and serve as unproductive storage. The balance between shade and sunlight is crucial for their development [3].

Guava bears flowers either singly or in clusters, growing on new growth from the leaf axils. It takes approximately one month for the flowers to fully develop from bud differentiation to the calyx cracking stage [4]. Pruning is a crucial practice that influences the tree's canopy, productivity, and fruit quality. Various studies have shown that the degree of pruning has a significant impact on the growth, flowering, quality, and yield of guava [5-7]. Early pruning helps establish a sturdy framework capable of bearing a heavy crop load. Pruning on bearing trees provides various advantages, including promoting new shoot formation, preventing branch overcrowding, and eliminating disease, crisscrossing, water sprouts, and root suckers. Failure to prune guava trees prolongs their vegetative growth, reduces the bearing area, and results in smaller fruits, decreased yield, and inferior quality. Hence, pruning is necessary to achieve a balance between vegetative and reproductive growth [8].

The activation of shoot tips relies on their ability to export auxin into the main stem, resulting in competition among these shoot tips, ultimately impacting their growth. The dominance of robust branches isn't solely attributable to their apex position but also their early establishment. Additionally, the primary growing shoot can suppress lower shoots, and the practice of pruning actively promotes branch development. Pruning serves multiple purposes, including rejuvenating plants, resource conservation, and enhancing the visual appeal of orchards, thereby reducing the incidence of flower and fruit drops [9]. This study aims to know the impact of different levels of pruning, age of plants, and their interaction effects on shoot length, initiation of flowering, flower bud emergence to anthesis, number of flowers per shoot, fruit set percentage, yield, fruit weight, TSS, acidity, TSS acid ratio, sugars, and ascorbic acid.

Materials and Method

Experimental details

The experiment was conducted for two consecutive years 2021-22 and 2022-23 at the guava (cv. Allahabad Safeda) orchard of the horticultural farm of Lovely Professional University, Phagwara during the rainy season to determine the impact of different pruning levels at different ages of guava plants.

The experiment was designed in 3 × 2 factorial RBD with two factors viz., pruning levels A and age of guava trees B. The pruning treatments consisted of three levels: A_1 (no pruning), A_2 (pruning of shoots at 10 cm), and A_3 (pruning of shoots at 20 cm). Plants from two different age groups were included in the study: B_1 (9 years old) and B_2 (11 years old).

Observations details

Average shoot length (cm)

For each replication, four shoots per plant were selected randomly from East, West, North, and South directions for measurement of length. The average length was calculated as the mean value of the shoot in centimeters using a measuring scale.

Days taken for initiation of flowering

The number of days taken for the first fully opened pair of flowers to appear on the pruned shoots, starting from the day of pruning was recorded.

Duration from lower bud emergence to anthesis

The number of days from the emergence of lower buds to the opening of flowers was counted to determine the duration of flowering.

Average number of flowers per shoot

The number of flowers per shoot from each replication in all directions was counted. By calculating the mean value of the counted flowers, the number of flowers per branch was expressed as an average numerical value. Four shoots in the East, West, North, and South directions were selected, and the number of flowers on each of them and the number of fruits on each labeled shoot were counted.

Fruit set (%)

The number of flowers per shoot and the number of fruits on each labeled shoot were counted, and the fruit set was estimated in percentage. This methodology allowed for accurate determination of the fruit set based on the number of flowers and fruits on the labeled shoots.

$$\text{Fruit set (\%)} = \frac{\text{Number of flowers per shoot} - \text{number of fruits per shoot}}{\text{Number of flowers per shoot}} x100$$

Fruit yield (kg/plant)

The total yield of fruits at each harvest was weighed for each tree on an electronic weighing balance. The final yield per tree in kg was obtained by summing up the yield of all pickings and expressed in kg per plant.

Physico-chemical attributes of guava fruits

After harvesting five fruits of uniform size were selected from each replication and treatment and brought to the laboratory for analysis of physico-chemical attributes. The fruit weight of each fruit was measured by using an electronic balance and the average was taken and expressed as grams per fruit. The juice of fruits was extracted for analysis of chemical parameters. TSS was estimated by using a hand refractometer and was expressed in °Brix. Titratable acidity was estimated by using N/10 NaOH solution. TSS: Acid ratio was estimated by dividing TSS by the titratable acidity of the fruit. Ascorbic acid was estimated by using 2,6-dichlorophenol indophenol as described by AOAC [10] and sugar content was estimated by using the procedure outlined in Ranganna [11]

Statistical analysis

The data underwent statistical analysis using OPSTAT software. The mean values of the observations were analyzed using the factorial randomized block design method to compare means and assess the statistical significance of treatments. The experiment involved six different treatment combinations, each replicated five times. To test the significance of variation among different treatments, the recorded mean values of all the quantitative traits for each replication were subjected to statistical analysis using the F-test method.

Results and Discussion

Average shoot length (cm) after pruning of guava trees

A significant effect of pruning level was reported on shoot length with the highest shoot length (11.26 cm, 11.41 cm, and 11.34 cm) after a higher level of pruning (20 cm) (Table 1). Furthermore, the effect of pruning on relatively older plants (11 years old) was more prominent and significant in comparison to 9 years old plants which could be associated presence of a greater level of stored photosynthates and early activation of vegetative buds in older plants due to pruning. The pruning results in the development of a localized sink towards the existing vegetative buds resulting in the diversion of stored nutrients towards the vegetative buds ensuring timely initiation of shoots. This is also associated with the mobilization of photosynthates from the apical portion to the axillary part resulting in the forced growth of buds. The length of new shoots was significantly higher in all pruning intensities compared to the absence of pruning. The greatest cumulative length of new shoots was noticed after severe pruning, followed by moderate and light pruning [12]. Nevertheless, the absence of a significant interaction between pruning and age confirms that the combined influence of pruning level and age on shoot growth did not demonstrate a significantly greater effect when compared to their individual effects (Figure 1).

Days taken for initiation of flowering in guava after pruning

The initiation of the flowering process was notably influenced by two primary variables: the intensity of pruning and the age of the guava trees (Table 1). Guava plants pruned to a length of 20 cm (A_3) exhibited a shorter time to induce flowering (average 65.55 days). In contrast, non-pruned guava plants (A_1) took the longest time to initiate flowering in the combined analysis. Notably, the impact of pruning was more pronounced on older plants (11 years old) than on 9-year-old ones. This could be attributed to the higher levels of stored photosynthates and earlier activation of vegetative buds resulting from pruning. However, the interaction between pruning and age did not yield significant results, suggesting that their combined effect on the initiation of flowering was less influential than the individual effect of each factor (Figure 1). The intensity of pruning has a strong influence over the shifting of vegetative primordia into reproductive primordia resulting in early initiation of flowers in guava plants after pruning, further, the initiation of flowers at 20 cm of pruning was earlier in comparison to pruning up to 10 cm and control [13,14]. Pruning aids in stimulating the emergence of fresh growth and blossoms by redirecting the plant's energy and resources toward its development. Additionally, the newly formed shoots contain a higher concentration of growth hormones crucial for flower initiation. Pruning also enhanced the penetration of sunlight into the tree's interior, leading to improved flowering. Trees that were spaced farther apart and subjected to pruning exhibited the shortest flowering duration, possibly due to increased sunlight exposure, enhanced nutrient availability, and improved air circulation, all of which promoted flower initiation [15].

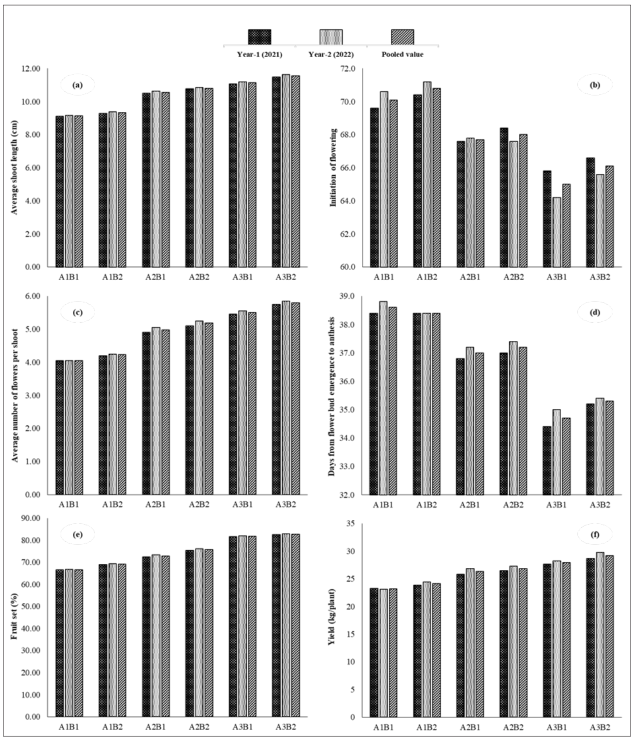

Figure 1: Interaction effect of pruning level and tree age on plant growth, flowering, fruiting, and yield characteristics of guava trees (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning, B_1 - 9 years old plants, B_2 - 11 years old plants).

Table 1: Shoot growth and flower initiation in guava plants after pruning of trees of different ages.

Factors	Average shoot length (cm)			Initiation of flowering		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
Factor A						
A_1	9.19^c	9.28^c	9.24^c	70.00^a	70.90^a	70.45^a
A_2	10.61^b	10.75^b	10.69^b	68.00^b	67.70^b	67.85^b
A_3	11.26^a	11.41^a	11.34^a	66.20^c	64.90^c	65.55^c
CD (at 0.05)	0.22	0.19	0.10	1.10	1.16	0.76
Factor B						
B_1	10.21^b	10.34^b	10.28^b	67.67^a	67.53^a	67.60^b
B_2	10.49^a	10.63^a	10.57^a	68.47^a	68.13^a	68.30^a
CD (at 0.05)	0.18	0.16	0.08	NS	NS	0.62

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

Duration from bud emergence to anthesis after pruning

The number of days taken from flower bud emergence to anthesis confirms the significant effect of pruning on guava trees (Table 2). The minimum number of days was recorded after pruning of shoot up to 20 cm (A_3) which was similar in both the years of observation as well as pooled values. Pruning promotes the development of fresh shoots and triggers flower formation in guava trees. However, there was no significant effect of the age of trees or interaction between age and pruning level on the duration between bud emergence to anthesis (Figure 1). Pruning fosters the development of fresh vegetative shoots, thereby increasing the abundance of flower buds on guava trees. Consequently, this expedites the appearance of flower buds and the onset of anthesis. Nevertheless, the precise impact of pruning on the timing of flower bud emergence and anthesis may vary across different levels of pruning intensity [16]. This amplified effect can be attributed to the greater accumulation of stored photosynthates and the earlier activation of vegetative buds in older plants as a result of pruning.

Average number of flowers per shoot after pruning

The number of flowers per shoot significantly increased with the level of pruning (Table 2). The highest number of flowers was observed in plants subjected to 20 cm pruning (A_3) during both years and the pooled data, respectively. The influence of pruning on flowering was more pronounced and significant in 11-year-old guava plants compared to 9-year-old ones. However, the interaction between pruning and plant age did not yield statistically significant results, indicating that the combined impact of pruning level and age on the growth of the shoot was not significantly greater than the individual effects of each factor (Figure 1). Pruning generally enhances flower production in guava trees by stimulating potentially fruit-bearing shoots, thereby increasing the number of flowers per shoot. Moreover, pruning exerts a beneficial influence on the overall well-being and canopy of the tree, optimizing the energy reserves available for the flowering process. When determining the appropriate pruning regimen, it is crucial to consider the specific requirements and growth patterns of guava trees [17]. The favorable effects of pruning on tree growth and flowering can be attributed to a higher rate of stomatal conductance in comparison to unpruned trees [15].

Fruit set (%) in guava after pruning

The intensity of pruning (Table 3) showed a clear and positive relationship with the average fruit set. The highest fruit set was estimated in plants after 20 cm of pruning (A_3),

Table 2: Various flowering attributes in guava plants after pruning of trees of different ages.

Factors	Days from flower bud emergence to anthesis			Average number of flowers per shoot		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
Factor A						
A_1	38.40^a	38.60^a	38.50^a	4.13^c	4.15^c	4.14^c
A_2	36.90^b	37.30^b	37.10^b	5.00^b	5.15^b	5.08^b
A_3	34.80^c	35.20^c	35.00^c	5.60^a	5.70^a	5.65^a
CD (at 0.05)	0.83	1.16	0.69	0.21	0.20	0.15
Factor B						
B_1	36.53^a	37.00^a	36.77^a	4.80^b	4.88^b	4.84^b
B_2	36.87^a	37.07^a	36.97^a	5.02^a	5.12^a	5.07^a
CD (at 0.05)	NS	NS	NS	0.17	0.16	0.12

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

Table 3: Fruit set (%) and yield (kg/plant) in guava plants after pruning of trees of different ages.

Factors	Fruit set (%)			Yield (kg/plant)		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
Factor A						
A_1	67.80^c	68.08^c	67.94^c	23.53^c	23.79^c	23.66^c
A_2	73.97^b	74.73^b	74.35^b	26.14^b	27.06^b	26.60^b
A_3	82.11^a	82.43^a	82.27^a	28.14^a	28.99^a	28.57^a
CD (at 0.05)	2.43	1.39	1.47	0.59	0.73	0.57
Factor B						
B_1	73.56^b	74.00^b	73.78^b	25.56^b	26.08^b	25.82^b
B_2	75.70^a	76.16^a	75.93^a	26.31^a	27.15^a	26.73^a
CD (at 0.05)	1.98	1.14	1.20	0.48	0.60	0.46

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

followed closely by those with 10 cm pruning (A_2), while the lowest fruit set was consistently found in non-pruned plants (A_1). Further, the impact of pruning was more prominent on older plants (11 years old) as compared to the 9-year-old ones. This could be attributed to the higher accumulation of stored photosynthates and the earlier activation of vegetative buds in older plants resulting from the pruning process. However, the interaction between pruning and age did not yield statistically significant results, indicating that the combined influence of pruning level and age of the plant on the fruit set was not superior to the individual effects of each factor (Figure 1). Careful pruning, which involves the selective removal of branches and leaves, effectively opens the tree canopy. This allows an increased influx of solar radiation and nutrients to reach the fruit branches, resulting in a greater percentage of fruit set. However, excessive, or severe pruning beyond the recommendation was reported to be harmful and might be accountable for lower fruit set percentage [18, 19]. Several studies have reported that pruning guava trees leads to a higher number of flowering shoots and an increased fruit set percentage compared to unpruned trees. This effect may be attributed to accelerated growth, improved sunlight availability for photosynthesis, and alterations in the actions of growth regulators like IAA, which contribute to enhanced fruit sets in guava [3, 20]. The effect of pruning was more visualized in older trees in comparison to younger ones which could be associated with the accumulation of stored photosynthates and metabolites in older plants.

Yield (kg/plant) of guava trees after pruning

A substantial influence of pruning and the age of the plant was observed on the yield of guava trees (Table 3). Guava plants subjected to 20 cm of pruning (A_3) demonstrated the highest yield while the lowest was estimated in plants without pruning. Moreover, the impact of pruning was found to be more substantial and noteworthy on older guava plants (11 years old) compared to younger plants (9 years old). This difference may be attributed to the higher level of photosynthesis and early activation of vegetative buds in older plants resulting from pruning. However, the interaction between pruning and plant age did not yield statistically significant results, indicating that the combined effect of pruning level and age of plants on the growth of shoots is not significantly greater than the individual effects of each factor (Figure 1). Increased pruning severity led to higher fruit weight, primarily due to the greater number and increased surface area of active leaves, resulting in enhanced photosynthate production [19]. Consequently, this substantial increase in fruit size and weight can be attributed to the increased availability of nutrients [21, 22]. Consistently, the highest fruit weight was observed in trees subjected to more extensive pruning (20 cm). This outcome can be attributed to the reallocation of resources, reduced competition, balanced growth, and improved light penetration, all of which contribute to higher fruit yield by directing resources toward fruit production, thus facilitating optimal development and efficient photosynthesis. Previous studies have also reported similar findings of larger fruit sizes in pruned guava plants compared to control plants [5, 23-26]. However, the impact of pruning was more pronounced in older trees, with a noticeable difference in yield, favoring 11-year-old trees over 9-year-old ones. This difference may be attributed to higher levels of photosynthesis and earlier activation of vegetative buds in older plants following pruning. It could also be linked to a more balanced regulation of nutrients and hormones in older trees compared to younger ones.

Physico-chemical attributes of guava fruits harvested from pruned trees

The highest fruit weight was consistently observed in trees with a greater extent of pruning (20 cm) owing to redistribution of resources, reduced competition, balanced growth, and improved light penetration (Table 4). Moreover, the impact of pruning on older plants (11 years old) was notably more pronounced and significant compared to 9-year-old plants. However, the interaction between pruning and age was found to be statistically insignificant, indicating that the cumulative effect of pruning and age of trees on fruit weight was not substantially greater than the individual effects of each factor (Figure 2). This could be associated with the mobilization of photosynthates from the site of synthesis to the sink i.e. growing fruit after pruning in older guava trees [27]. The highest mean TSS (10.05 °Brix) was observed after pruning at 20 cm of apical shoots (Table 4). The TSS content of fruits exhibited significant variations across different seasons. Furthermore, the impact of pruning on older plants (11 years old) was no-

Table 4: Fruit weight (g) and TSS (°Brix) of guava fruit after pruning of trees of different ages.

Factors	Fruit weight (g)			TSS (°Brix)		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
Factor A						
A_1	114.24^c	114.30^c	114.27^c	9.40^c	9.44^c	9.42^c
A_2	121.93^b	122.85^b	122.39^b	9.62^b	9.82^b	9.72^b
A_3	126.63^a	127.85^a	127.24^a	9.96^a	10.13^a	10.05^a
CD (at 0.05)	1.78	1.76	1.62	0.042	0.056	0.036
Factor B						
B_1	119.47^b	120.40^b	119.94^b	9.64^b	9.64^b	9.77^b
B_2	122.40^a	122.93^a	122.67^a	9.68^a	9.68^a	9.83^a
CD (at 0.05)	1.46	1.43	1.32	0.035	0.046	0.029

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

tably more pronounced and significant compared to 9-year-old plants. However, the interaction between pruning and age was found to be statistically insignificant, indicating that the cumulative effect of pruning level and the age of trees on TSS was not substantially greater than the individual effects of each factor (Figure 2). The improvement in TSS content in guava after pruning is attributed to enhanced photosynthesis and nutrient uptake, which is accountable for increased accumulation of sugars, resulting in higher TSS levels. Moreover, the pruned plants exhibited a relatively greater ratio of leaves to fruit in comparison to the unpruned plants which played a role in elevating the concentration of TSS due to an enhanced synthesis of metabolites [3, 28].

The recorded observation on acidity indicates that the pruning level of guava trees has a significant influence, and the minimum acidity (0.32%) was reported at a higher extent of pruning (20 cm) while the maximum acidity was recorded in control (0.39%) (Table 5). Moreover, when examining the impact of pruning on guava plants of different ages, it was found that there was no significant effect of tree age and its interaction with the pruning level on the acidity of fruits (Figure 2). The TSS: acid ratio in guava is directly linked to fruit quality. Pruning of guava trees with high intensity (20 cm pruning) showed a higher TSS: acid ratio (31.48) as compared to unpruned trees (24.35), indicating improved TSS levels and reduced acidity due to pruning (Table 5). Furthermore, there was no significant difference in the TSS: acid ratio in fruits from either pruned or unpruned plants of different ages. Furthermore, the statistical analysis revealed that the interaction between pruning level and age lacked significance (Figure 2). The reduction of titratable acidity with higher pruning intensity is possibly due to the accumulation of a greater amount of acid synthesized and accumulated in the newly developed leaves during fruit development. The improvement in fruit quality resulting from pruning is attributed to several factors, including improved sunlight penetration, increased leaf area, and higher chlorophyll content. Furthermore, ensuring a balanced fruit load in guava trees contributes to the improvement of fruit quality [9, 29, 30]. Further, the unpruned plants had a lower TSS: acid ratio due to slower starch-to-sugar conversion, competition, and limited light exposure [31, 32].

The results of this investigation highlighted a notable correlation between the extent of pruning and sugar content (total sugar and the reducing sugars) (Table 6). The maximum total sugars and reducing sugar (6.56% and 3.80%, respectively) were observed in trees subjected to higher levels of pruning (20 cm), while the control group (no pruning) exhibited the minimum total sugars (6.30% and 3.66%, respectively) as pooled value. However, results indicated that there was a non-significant effect of the age of plants on total sugars and the reducing sugar content of guava fruits. Additionally, the lack of significance in the interaction between pruning and

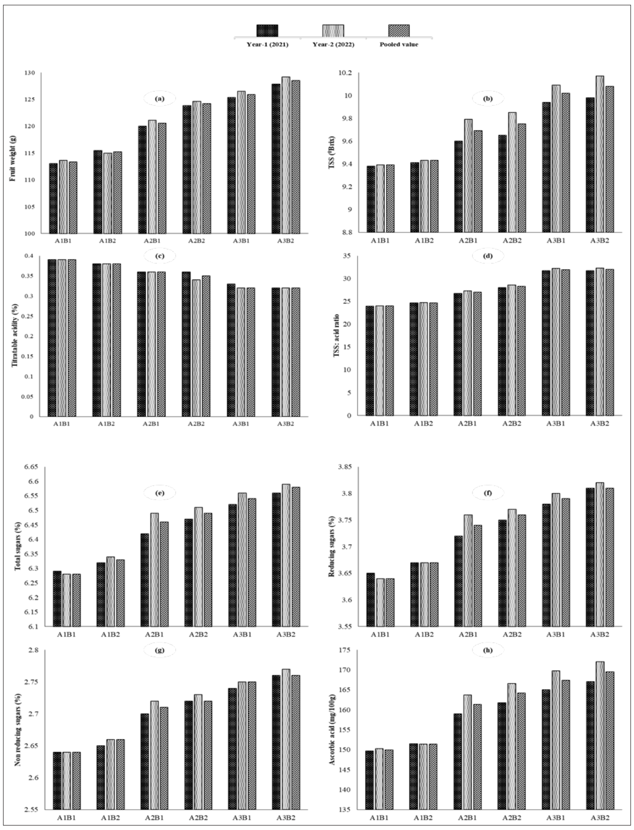

Figure 2: Interaction effect of pruning level and tree age on physicochemical characteristics of guava fruits (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning, B_1 - 9 years old plants, B_2 - 11 years old plants).

Table 5: Titratable acidity and TSS acid ratio of guava fruits after pruning of trees of different ages.

Factors	Titratable acidity (%)			TSS acid ratio		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
			Factor A			
A_1	0.39[a]	0.39[a]	0.39[a]	24.28[c]	24.43[c]	24.35[c]
A_2	0.36[b]	0.35[b]	0.36[b]	26.85[b]	27.90[b]	27.37[b]
A_3	0.32[c]	0.32[c]	0.32[c]	30.75[a]	32.20[a]	31.48[a]
CD (at 0.05)	0.011	0.023	0.013	0.95	1.73	1.05
			Factor B			
B_1	0.36[a]	0.36[a]	0.36[a]	26.96[a]	27.81[a]	27.38[a]
B_2	0.35[a]	0.35[a]	0.35[a]	27.63[a]	28.54[a]	28.08[a]
CD (at 0.05)	NS	NS	NS	NS	NS	NS

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

Table 6: Sugar content (%) of guava fruits after pruning of trees of different ages.

Factors	Total sugars (%)			Reducing sugars (%)		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
Factor A						
A_1	6.30^b	6.30^b	6.30^b	3.65^b	3.66^b	3.66^b
A_2	6.45^a	6.50^a	6.47^a	3.74^a	3.77^a	3.75^a
A_3	6.54^a	6.57^a	6.56^a	3.80^a	3.81^a	3.80^a
CD (at 0.05)	0.156	0.171	0.125	0.090	0.099	0.072
Factor B						
B_1	6.41^a	6.44^a	6.42^a	3.72^a	3.74^a	3.73^a
B_2	6.45^a	6.48^a	6.46^a	3.74^a	3.75^a	3.75^a
CD (at 0.05)	NS	NS	NS	NS	NS	NS

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

Table 7: Non-reducing sugar and ascorbic acid content (%) of guava fruits after pruning of trees of different ages.

Factors	Non reducing sugars (%)			Ascorbic acid (mg/100 g)		
	Year - 1	Year - 2	Pooled value	Year - 1	Year - 2	Pooled value
Factor A						
A_1	2.65^b	2.65^b	2.65^b	150.58^c	150.84^c	150.71^c
A_2	2.71^a	2.73^a	2.72^a	160.40^b	165.19^b	162.79^b
A_3	2.75^a	2.76^a	2.76	166.04^a	170.92^a	168.48^a
CD (at 0.05)	0.067	0.071	0.053	1.90	1.61	1.71
Factor B						
B_1	2.70^a	2.71^a	2.70^a	157.92^b	161.28^b	159.60^b
B_2	2.71^a	2.72^a	2.72^a	160.10^a	163.35^a	161.73^a
CD (at 0.05)	NS	NS	NS	1.55	1.32	1.39

Note: NS - nonsignificant; Distinct letters (a, b, c) within the columns indicate significant differences (Tukey's test, $p \leq 0.05$) and reflect the impact of treatment during the same time interval; A represents pruning levels (A_1 - no pruning, A_2 - 10 cm pruning, A_3 - 20 cm pruning); B represents the age of guava trees (B_1 - 9 years old plants, B_2 - 11 years old plants); Year - 1 (2021); and Year - 2 (2022).

age confirms that the combined effect of shoot pruning and age on shoot growth did not exceed the individual effects on guava's total sugar content (Figure 2). Similar to the total sugar and reducing sugar content, the non-reducing sugar content of guava fruits was likewise influenced by varying pruning levels (Table 7). The trend of variation was also as per the trend of reducing sugar content. The positive impact of pruning on total sugars could be attributed to the enhanced allocation of stored nutrients towards the vegetative buds which might have promoted their timely initiation and contributed to an increase in the objectives of photosynthesis. Additionally, this phenomenon is linked to the transfer of photosynthates from the top section of the tree to the lateral branches, which stimulates bud growth. The higher levels of total and reducing sugars can be attributed to the increased leaf-to-fruit ratio in the pruning treatments. This, in turn, resulted in the enhanced synthesis of carbohydrates and other metabolites that were subsequently transported to the fruit tissues [33, 34]. This phenomenon may be due to the improved nutrient uptake in pruned trees, leading to increased carbohydrate and metabolite synthesis, with subsequent translocation to the fruits [28, 35]. These findings are consistent with previous research conducted on various fruits, such as custard apple and mango [36]. The significant correlation between pruning and the age of guava trees can be attributed to the higher levels of stored photosynthates and the early activation of vegetative buds in older plants resulting from pruning [37]. The rise in non-reducing sugar content in guava fruits after higher intensity of pruning could be attributed to the positive effects of pruning on photophosphorylation and the dark reaction of photosynthesis. As a result, there was an enhanced production of carbohydrates in the fruits, allowing for improved nutrient availability during fruit development and ultimately leading to higher levels of non-reducing sugars [29, 38].

The observations on the ascorbic acid content of guava fruits demonstrated a notable increase at higher pruning levels (20 cm) (168.48 mg/100 g), whereas the control group had the lowest ascorbic acid (150.71 mg/100 g) content in guava fruits (Table 7). The lowest amount of ascorbic acid was observed in no pruning treatment. The study found a significant correlation between pruning intensity and the age of guava trees, with a stronger impact on older trees (11 years old) compared to younger plants (9 years old). Pruning contributed to improved fruit quality and increased ascorbic acid content in older trees in comparison to younger ones. However, the interaction between pruning levels and age did not have a significant effect (Figure 2). Pruning improves fruit quality through better sunlight penetration, optimizing exposure for all parts of the tree, enhancing photosynthesis, and increasing carbohydrate production. Balanced fruit load and leaf-to-fruit ratio contribute to higher levels of sugars, soluble solids, and ascorbic acid in guava fruits [39-41].

Conclusion

The present study confirms the significant effect of pruning level on growth, yield, and fruit quality attributes in guava. The pruning intensity up to 20 cm was reported significant for older trees (11 years old) to improve plant growth, flower bud differentiation, flower initiation, fruiting, fruit set percentage, fruit production, and physico-chemical aspects of guava fruits. The pruning was observed as an essential practice in older guava trees for the removal of diseased and non-productive parts and mobilization of nutrients to ensure higher quality yield. Nevertheless, the interaction between pruning levels and tree age did not yield a significant effect.

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Conflict of Interest

None.

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