Research Article

Effect of Shoot Pruning on Growth, Flowering and Fruiting Characteristics of Different Guava (Psidium Guajava L.) Cultivars

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ABSTRACT
A field trial was conducted to study the effect of shoot pruning on growth, flowering and fruiting characteristics of different guava cultivars. The experiment was carried out during Jan. 2018 to June 2019. The experiment was laid out in Randomized Block Design (RBD) with seven cultivars as treatments including L-49 (T1), Allahabad Safeda (T2), Baruiupur (T3), Doodh Khaja (T4), Kafri (T5), Bhagalpur (T6) and Harichal (T7). Shoot pruning in guava is an alternative practice used to control the excessive growth and vigor of the plant. The plants were pruned from 120 cm above the ground level as heading back to facilitate the production of new shoots from below the cut point and allow the primary shoots. These results revealed that, guava cultivar baruiupur was best in terms of number of primary shoots (58.17), length of primary shoots (135.82 cm) at 12 months after pruning, flowering percentage (66.11%) and better fruit characteristics.

KEYWORDS
Heading back; vegetative buds; guava; rejuvenation; fruit quality

Introduction
Guava (Psidium guajava L.) also known as “apple of the tropics” or “poor man’s apple” is one of the popular fruit crops of tropical and subtropical climate. It belongs to the Myrtaceae family having chromosome number 2 n = 22 and is native to Tropical America, extending from Mexico to Peru. Guava is the fifth most important fruit with respect to area and production after mango, banana, citrus and papaya in India. The area under guava in India is about 262,000 hectares producing 3,648 million tonnes with a productivity of 13.9 MT/ha and commercially cultivated in the states of Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Punjab, Gujarat, Maharashtra, Karnataka and Andhra Pradesh (National Horticulture Board, 2017).

Guava is an ideal fruit crop for nutritional security in India. It is the third richest source of vitamin C (299 mg/100 g) after Barbados cherry (1000–4000 mg/100 g pulp) and Aonla (600 mg/100 g of pulp) (Gupta, 2014), and contains two to five times more vitamin C than oranges and 10 times more than tomato. It is also the second highest fiber (6.9%) containing fruit next to fig crop (Muthukumar and Selvakumar, 2017). In North Indian conditions, two distinct seasons of flowering occur in a year, April–May and August–September, in which fruits ripen during rainy and winter seasons, respectively (Mitra et al., 2008). Pruning of guava plants at 20 cm level in early May was the most effective management for guava crop regulation (Adhikari and Kandel, 2015).
Pruning is an important horticultural operation affecting the vegetative and floral behavior of many fruit crops by manipulating time of flush maturity and physiology (Zivdar et al., 2016). The main advantages of pruning on bearing trees include the formation of new shoots, avoidance of overcrowding of branches and removal of criss-cross branches, diseased branches as well as water sprouts and root suckers. Heading back and pinching were important factors to obtain the yield and quality fruits in high-density orchard of guava (Mehta et al., 2012; Sahay and Singh, 2001). Pruning aids in the improvement of crop and it can be used as the better means to enhance the fruiting potential of guava and increasing the production (Bajpai et al., 1973; Lal et al., 1996). Judicious pruning can be useful to make guava trees bear profitable crops year after year (Brar et al., 2007). Pruning will not only restore balance between shoot and root system but will also maintain growth and vigor of shoots by allowing only fewer growing points to grow vigorously and regulate the guava crop (Dubey et al., 2001). Shoot pruning greatly influenced the plant height, plant spread and stem girth of guava cv. Sardar ( Hiremath et al., 2017). The different soil and agro-climatic condition of West Bengal made pruning of different fruit crops for the betterment of canopy management and fruit yield. However, information on shoot pruning of different guava cultivars is scanty in West Bengal. Thus, the present work was formulated with an objective to study the effect of shoot pruning on growth, flowering and fruiting characteristics of different guava cultivars.

Materials and Methods

Experimental Site

The study was conducted at Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India, during 2018–19, which falls under the category of eastern sub-Himalayan plains (28° 58′86″ N latitude and 81°66′73″ E longitude, at an elevation of 42 m above mean sea level). The climate of the region is subtropical in nature with distinctive characteristics of high rainfall, high humidity and prolonged winter. There are broadly two dominant seasons in a year: extended winter or dry rabi season, and a long rainy season. The temperature range of this area varies from a minimum of 7.1–8.0°C to the maximum of 24.8–32.2°C. The soil is sandy loam in nature and coarse textured having poor water-holding capacity. The soil is organic carbon rich and has higher amount of available nitrogen while with medium in phosphorus and potash having acidic reaction (Table 1).

In this investigation, seven cultivars of guava were taken, and each cultivar was treated as individual treatment including L-49 (T1), Allahabad Safeda (T2), Baruipur (T3), Doodh Khaja (T4), Kafri (T5), Bhagalpur (T6) and Harichal (T7) with randomized block design (RBD), and three replications per treatment were followed during the experimentation. L-49 (T1) – It is the most popular variety in India. Fruits are spherical and meaty, seeds are soft and in plenty, and pulp is white and tasty. Allahabad Safeda (T2) – It is the progenitor of many Indian guava varieties, fruits are big in size, round, smooth skin, white pulp, soft, firm, light yellow, very sweet taste, pleasing flavor and has few seeds. Baruipur (T3) – Round with yellowish skin. Flesh is white, and has good taste and flavor. Doodh Khaja (T4) – Fruits are sub-globose in shape, straw yellow skin color with creamy white pulp. Kafri (T5) – Fruits are sub-globose and flattened base shape, yellowish green skin color with creamy white pulp. Bhagalpur (T6) – It is rich in antioxidants, black guava with red pulp and rich in minerals and vitamins. Harichal (T7) – Fruits are roundish with flattened base shape, creamy whitish pulp. Heading back at 120 cm height above the ground level was performed during Jan. 2018 to facilitate the emergence of new shoots from the below cut point for proper shaping of tree canopy and to enhance the production of quality fruits by using Falcon Chain Saw machine and performances of different parameters were recorded. The recommended dose of fertilizer (N:P:K) was applied to a ratio of 260:320:260 g/plant. The field was kept free from the weeds by manual weeding at the interval of 20 days. Flood irrigations were given as and when required, so that the plants did not suffer from drought conditions. The recommended fungicide and insecticides were applied for protection against diseases and insect, pests’ infestation.
**Table 1.** Chemical properties of the experimental soil.

| Particulars | Value | Method employed |
|-------------|-------|-----------------|
| pH          | 5.30  | The soil pH was determined in 1:2.5 soil water suspension by using Beckmen’s pH meter (Black, 1965) |
| Organic carbon (%) | 0.93  | Walkley and Black’s rapid titration method (Jackson, 1973) |
| N (kg ha\(^{-1}\)) Available | 210.58 | Alkaline; KMNO\(_4\) method developed by Subbiah and Asija (1956) |
| P (kg ha\(^{-1}\)) Available | 18.24 | Brays’ method-Bray and Kurtz, (Jackson, 1973) |
| K (kg ha\(^{-1}\)) Available | 110.38 | Flame Photometer method (Black, 1965) |

**Measurements of Growth Characteristics**

Growth parameters like days taken for the emergence of vegetative buds, total number of primary shoots, length of the primary shoot (cm), fresh weight and dry weight of primary shoot (g), carbohydrate content (anthrone method) and sugar content (Ranganna, 1986) of new shoots were recorded after shoot pruning.

*Flowering Characteristics:* The flowering characteristics were observed on the basis of all the plants of specific replication such as days taken for the emergence of first flower bud after pruning, number of flowering buds.

Flowering percentage: It was calculated using the following formula:

\[
\text{Flowering percentage} (\%) = \frac{\text{Number of flowers}}{\text{Number of flower buds}} \times 100
\]  

(1)

*Fruiting Characteristics:* The number of fruit set, total number of fruits, fruit weight (g), fruit diameter (cm) and fruit set percentage (%) were recorded. The fruit set percentage was recorded, and mean values presented as per cent fruit set. Fruit set percentage was calculated using the following formula:

\[
\text{Fruit set} (\%) = \frac{\text{Total number of fruits}}{\text{Total number of flowers}} \times 100
\]  

(2)

Fruit quality parameters like total soluble solids (TSS), total sugar (%), reducing sugar (%), ascorbic acid (mg/100 g) and titratable acidity (%) were determined by using fresh fruit samples under each treatment (Ranganna, 1986; Sadasivam and Manickam, 1992).

**Statistical Analysis**

For statistical interpretation, analysis of variance for each parameter was performed using Proc Glm of Statistical analysis System (SAS) software (Version 9.3). Means separation for different accessions under different parameters was performed using Least Significant Difference (LSD) test (P ≤ .05). Normality of residuals under the assumptions of ANOVA was tested using Kolmogorov–Smirnov test using Proc-Univariate procedure of SAS (Version 9.3).

**Results**

**Effect of Shoot Pruning on Growth Characteristics**

The days taken for the emergence of vegetative buds varied significantly (Figure 1) among the different cultivars. The cultivar Baruipur (54.83 days) required less days for the emergence of vegetative buds followed by Allahabad Safeda (54.33 days) and L-49 (54.50 days). It was found that Doodh Khaja (65.50) required maximum days for the emergence of vegetating buds followed by Kafri (65.00 days), Bhagalpur (64.83 days) and Harichal (63.67 days). Result
indicated that the cultivar Baruipur (54.83 days) was statistically at par with the cultivar L-49 (54.50 days) and Allahabad Safeda (54.33 days). The maximum number of primary shoots was recorded in Baruipur (58.17) followed by Kafri (46.83) and Doodh Khaja (46.67), and the lowest number of primary shoots was recorded in L-49 (31.83) which was statistically at par with Allahabad Safeda (36.33), Bhagalpur (37.00) and Harichal (38.17) (Figure 2). The cultivar Allahabad Safeda showed the maximum length of primary shoots (19.62 cm at 3 months after pruning and 63.06 cm at 6 months after pruning) (Figure 3). At the later stages, the number of primary shoots was maximum in Baruipur (94.94 cm at 9 months after pruning and 135.82 cm at 12 months after pruning). Data pertaining to fresh weight and dry weight of primary shoot indicated non-significant variation among different cultivars of guava. Fresh weight was maximum in Kafri (11.67), followed by Bhagalpur (11.64 g) which has been presented in Figure 4. Average data showed that fresh weight was the least in L-49 (8.83 g). Dry weight was maximum in Bhagalpur (4.50 g), followed by Baruipur (3.70 g) and the least dry weight of primary shoot was recorded with Harichal (3.30 g) which has been presented in Figure 4, but all the treatments are statistically at par with each other.
Significant variation is exhibited among the different guava cultivars with respect to carbohydrate content of new shoots. Maximum carbohydrate content was recorded with Baruipur (56.81 g), followed by Doodh Khaja (53.92 g) and L-49 (48.13 g), and minimum carbohydrate content was recorded with Allahabad Safeda (39.01 g) (Figure 5). The sugar content of new shoots was significant among the different cultivars of guava studied under this experiment and was recorded maximum with Baruipur (2.31%), followed by Doodh Khaja (2.26%) (Figure 6). The sugar content of Bhagalpur (2.09%) recorded the lowest, followed by Kafri (2.12%). The performance of guava cv. Baruipur and Allahabad Safeda was better in sugar content of shoots compared to other cultivars.

Flowering Characteristics

The days taken for the emergence of first flower bud after pruning of different cultivars of guava varied significantly (Table 2). Among the different cultivars, Baruipur recorded the lowest days taken for the emergence of first flower bud after pruning (223.33 days), followed
by Allahabad Safeda (228.50 days) and Doodh Khaja (230.40 days). Among all the cultivars, maximum days taken for the emergence of first flower bud after pruning was observed in Harichal (234.50 days) and Kafri (232.67 days). Significant variation was exhibited among the different cultivars of guava. The number of flowering buds was maximum in Doodh Khaja (132.67), and minimum number of flowering buds was recorded in L-49 (99.67), followed by Kafri (110.17) and Bhagalpur (110.83). Maximum number of flowering buds is a highly desirable character in guava plant that tends to produce more flowering. A significant variation in number of flowers was observed in the different cultivars of guava. The highest number of flowers was recorded in Doodh Khaja (132.67), and the least number of flowers was recorded in L-49 (76.17), followed by Kafri (86.67), Bhagalpur (110.83), Harichal (94.00), Baruipur (102.33) and Allahabad Safeda (102.50). The guava cv. Doodh Khaja performed better in this geographical region. This cultivar was good in terms of carbohydrate reserve and sugar content of the new shoots.
Table 2. Effect of shoot pruning on flowering and fruiting characteristics.

| Treatments       | Days taken for emergence of first flower bud after pruning | Number of flowering buds | Number of flowers | Flowering percentage (%) | Number of fruit set | Fruit set percentage (%) |
|------------------|----------------------------------------------------------|--------------------------|-------------------|---------------------------|---------------------|--------------------------|
| T₁ (L-49)        | 230.50<sup>ab</sup>                                    | 99.67<sup>b</sup>       | 76.17<sup>a</sup>  | 60.76<sup>a</sup>        | 37.33<sup>ab</sup>  | 44.19<sup>b</sup>         |
| T₂ (Allahabad Safeda) | 228.50<sup>ab</sup>                               | 124.50<sup>ab</sup>     | 102.50<sup>ab</sup>| 65.65<sup>ab</sup>       | 60.83<sup>a</sup>  | 60.02<sup>ab</sup>         |
| T₃ (Baruipur)    | 223.33<sup>b</sup>                                    | 122.00<sup>ab</sup>     | 102.33<sup>ab</sup>| 66.11<sup>a</sup>        | 55.67<sup>b</sup>  | 54.76<sup>bc</sup>         |
| T₄ (Doodh Khaja) | 230.40<sup>ab</sup>                                   | 132.67<sup>a</sup>      | 107.17<sup>a</sup> | 63.98<sup>a</sup>        | 57.83<sup>b</sup>  | 57.96<sup>bc</sup>         |
| T₅ (Kafri)       | 232.67<sup>a</sup>                                    | 110.17<sup>ab</sup>     | 86.62<sup>ab</sup> | 62.23<sup>a</sup>        | 49.17<sup>b</sup>  | 52.54<sup>bc</sup>         |
| T₆ (Bhagalpur)   | 232.17<sup>a</sup>                                    | 110.83<sup>ab</sup>     | 90.17<sup>ab</sup> | 64.30<sup>a</sup>        | 54.50<sup>b</sup>  | 55.01<sup>bc</sup>         |
| T₇ (Harichal)    | 234.50<sup>a</sup>                                    | 125.17<sup>ab</sup>     | 94.00<sup>ab</sup> | 60.41<sup>a</sup>        | 67.33<sup>ab</sup> | 73.20<sup>a</sup>          |
| S.Em. (±)        | 2.61                                                    | 9.76                     | 9.24              | 2.11                      | 6.22                | 4.94                     |
| L.S.D (P ≤ .05)  | 8.06                                                    | 30.08                    | 28.48             | NS                        | 19.19               | 15.25                    |

**Means with the same letter are not significantly different; values in a parenthesis are arc sine value.

The performance of Baruipur regarding the flowering percentage was excellent (66.11) and it nonsignificantly differed from all other cultivars studied in the experiment, followed by Allahabad Safeda (65.65), Bhagalpur (64.30), Doodh Khaja (63.98), Kafri (62.23), L-49 (60.76) and Harichal (60.41). Higher percentage of flowering is most desirable in guava to produce uniform flowering. Higher percentage of flowering in Baruipur may be due to the environment sensitivity, particularly light intensity and temperature on plants.

Fruits Set and Fruit Quality Characteristics

There were significant differences of different guava cultivars with respect to number of fruit set. It was observed that Harichal recorded the highest number of fruit set (67.30) followed by Allahabad Safeda (60.83), and the lowest number of fruit set was recorded with L-49 (37.33). Fruit set percentage was high in Harichal (73.20%), followed by Allahabad Safeda (60.02%) and Doodh Khaja (57.96%). It was also observed that L-49 (44.20%) showed the lowest fruit set percentage. The maximum fruit weight (180.83 g), fruit diameter (6.79 cm), TSS (9.6 °B), total sugar (8.41%), reducing sugar (2.95%), acidity (0.28%) and ascorbic acid (185.25 mg/100 g) were recorded in Baruipur (T₃) followed by Doodh Khaja (T₄)(Table 3).

Discussion

In this context, the guava cv. Baruipur was more responsive for the emergence of vegetative buds on heading back at 120 cm compared to other cultivars (Figure 7). The variation in vegetative bud emergence may be due to the differences of carbohydrate reserve present on cultivars. Similar results

Table 3. Effect of shoot pruning on fruit quality characteristics.

| Treatments       | Fruit weight (g) | Fruit diameter (cm) | TSS (°B) | Reducing sugar (%) | Total sugar (%) | Ascorbic acid (mg/100 g) | Acidity (%) |
|------------------|------------------|---------------------|----------|--------------------|-----------------|--------------------------|-------------|
| T₁ (L-49)        | 169.41<sup>ab</sup> | 5.77<sup>c</sup>  | 8.73<sup>bc</sup> | 2.85<sup>ab</sup> | 7.35<sup>b</sup> | 175.22<sup>bc</sup> | 0.23<sup>b</sup> |
| T₂ (Allahabad Safeda) | 158.25<sup>bc</sup> | 5.92<sup>c</sup>  | 8.60<sup>c</sup> | 2.68<sup>bc</sup> | 7.28<sup>bc</sup> | 172.58<sup>c</sup> | 0.22<sup>b</sup> |
| T₃ (Baruipur)    | 180.83<sup>a</sup> | 6.79<sup>a</sup>  | 9.60<sup>a</sup> | 2.95<sup>a</sup>  | 8.41<sup>a</sup> | 185.25<sup>a</sup> | 0.28<sup>a</sup> |
| T₄ (Doodh Khaja) | 176.25<sup>ab</sup> | 6.39<sup>b</sup>  | 9.00<sup>b</sup> | 2.87<sup>ab</sup> | 8.15<sup>b</sup> | 179.50<sup>b</sup> | 0.23<sup>b</sup> |
| T₅ (Kafri)       | 157.00<sup>bc</sup> | 5.81<sup>c</sup>  | 8.40<sup>c</sup> | 2.54<sup>cd</sup> | 7.05<sup>bcd</sup>| 165.20<sup>d</sup> | 0.21<sup>bc</sup> |
| T₆ (Bhagalpur)   | 141.41<sup>d</sup> | 5.19<sup>d</sup>  | 8.00<sup>d</sup> | 2.32<sup>d</sup>  | 6.83<sup>cd</sup>| 159.28<sup>bc</sup> | 0.17<sup>c</sup> |
| T₇ (Harichal)    | 149.25<sup>bc</sup> | 5.32<sup>c</sup>  | 8.00<sup>d</sup> | 2.62<sup>bcd</sup>| 6.73<sup>d</sup> | 165.20<sup>d</sup> | 0.18<sup>c</sup> |
| S.Em. (±)        | 3.80              | 0.08                | 0.12      | 0.09               | 0.15            | 1.43                    | 0.01        |
| L.S.D (P ≤ .05)  | 11.72             | 0.26                | 0.39      | 0.30               | 0.49            | 4.43                    | 0.04        |

**Means with the same letter are not significantly different.**
were obtained by Bajpai et al. (1973), Dhaliwal and Kaur (2003) and Jadhav et al. (1998) who studied the effect of pruning on plant growth of guava. Usually, heading cut tends to stimulate more vegetative growth from the remaining parts of the plant. The guava cv. Baruipur is considered the commercial cultivar of West Bengal due to its more local geographical adaptability. Apart from this, the maximum carbohydrate content (56.81 g) and sugar content (2.31%) were observed in guava cv. Baruipur, which leads the expression of number of primary shoots compared to other cultivars. The variation of number of shoots and growth percentage among different cultivars was also observed (Thapa, 2014). The maximum length of shoot (10.62 cm) of Allahabad Safeda was attained in 90 days from bud initiation, and Sardar cultivar produced superior leaves than Allahabad Safeda cultivar. Sardar took shorter period (69 days) for producing leaves than Allahabad Safeda (81 days) counted from the date of leaf initiation (Symmal et al., 1976). The performance of guava cv. L-49 and Allahabad Safeda was better in terms of shoot length after pruning (Symmal et al., 1976). Plant growth and development might also be affected by the supply of carbohydrate and might compete for limited resources with

![Figure 7](image-url)

**Figure 7.** Comparison of shoot pruning of different guava cultivars.
other sinks. The result also indicated that the performance of guava cv. Doodh Khaja, Kafri, Bhagalpur and Harichal was poor in terms of length of primary shoots throughout the course of investigation. The local cultivar Baruipur showed the maximum carbohydrate content due to its better adoption in this locality and more vigorous nature.

The performance of guava cv. Baruipur and Allahabad Safeda was better in terms of sugar content of shoots compared to other cultivars. Total sugars and reducing sugars were also higher in the bending/pruning treatments; for starch, however, it followed a reverse trend. Likewise, total phenol content in leaves and bark was greater in the control compared to other treatments, and findings of carbohydrate and sugar content were supported by Bagachi et al. (2008). The longer age (148.33 days) of flowering shoot in Sardar cultivar of guava was found with 30 cm pruning, whereas the age of flowering shoot of guava for winter season decreased by delaying pruning and significant increases in age of flowering shoot by different pruning intensities relative to the control. The maximum flowering bud per shoot was observed with the treatment of 60 cm pruning severity in guava cv. L-49 (Mohammed et al., 2006). The maximum number of flowers per plant was recorded in Allahabad Safeda (7.60), followed by L-49 (Sardar) and Arka Amulya (Bhagat, 2014). The weather condition was also playing a major role in flower pollination and fruit set; the occurrence of high temperatures or other adverse factors could affect the pollination due to pollen and stigma susceptibility. The maximum fruit weight, fruit diameter, TSS, total sugar, reducing sugar, acidity and ascorbic acid were recorded in T3 (Baruipur), followed by T4 (Doodh Khaja). Furthermore, shoot pruning improves the light penetration inside the canopy and increases the rate of photosynthesis. This could have improved the fruit quality of guava trees. The maximum fruit set and fruit yield were observed at a pruning height of 1.5 m, and more pruning intensity leads to reduced fruit set and fruit quality (Kohli et al., 2017). Our results suggest that shoot pruning may be the main factor for improving the vegetative growth, source–sink relationship, photosynthetic capacity of new shoots, and flowering and fruit quality characteristics of different guava cultivars, leading to heavier and better yields.

**Conclusion**

Our data showed that the effect of shoot pruning on vegetative growth was better in guava cv. Doodh Khaja, and guava cv. Baruipur had shown positive influence on flowering and fruiting characteristics. Hence, it may be concluded that under sub-Himalayan terai region of West Bengal, shoot pruning of guava cv. Baruipur could be adopted for controlling and managing the excessive growth and vigor of the plant which ultimately helped in enhancing the production and productivity of the guava trees.

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**Disclosure Statement**

No potential conflict of interest was reported by the author(s).

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