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Effect of season of softwood grafting on grafts success and subsequent growth in guava (*Psidium guajava* L.) under Konkan agro-climatic condition of Maharashtra

SD Ranaware, SL Ghavale, KV Malshe, SB Thorat, PM Haldankar and AV Mane

Abstract
Field experiment on effect of season of softwood grafting on grafts success and subsequent growth in guava (*Psidium guajava* L.) Cv. Sardar (L-49)' was carried out at College of Horticulture, Dr. B.S.K.K.V. Dapoli, Dist. Ratnagiri during the year 2022-2023 to find out the appropriate season of softwood grafting for minimized the days to sprouting, higher grafts success percentage, final survival percentage and subsequent growth of guava grafts under Konkan agro-climatic condition. Experiment was laid out in randomized block design with sixteen treatments *viz*., T_1:Grafting in 1st fortnight of August, T_2:Grafting in 2nd fortnight of August, T_3:Grafting in 1st fortnight of September, T_4:Grafting in 2nd fortnight of September, T_5:Grafting in 1st fortnight of October, T_6:Grafting in 2nd fortnight of October, T_7:Grafting in 1st fortnight of November, T_8:Grafting in 2nd fortnight of November, T_9:Grafting in 1st fortnight of December, T_{10}:Grafting in 2nd fortnight of December, T_{11}:Grafting in 1st fortnight of January, T_{12}:Grafting in 2nd fortnight of January, T_{13}:Grafting in 1st fortnight of February, T_{14}:Grafting in 2nd fortnight of February, T_{15}:Grafting in 1st fortnight of March, T_{16}:Grafting in 2nd fortnight of March which were replicated 2 times. The minimum days to sprouting, sprouting pattern, sprouting and survival percentage and subsequent growth parameters were measured. Results revealed that among different season of softwood grafting in guava, the grafting in 1st fortnight of November (T_7) were found significant and superior for most of the parameters including minimum days to sprouting (16.0 days), maximum sprouting percentage (73.0%), and subsequent growth parameters like graft height (63.58 cm), stem girth (9.6 mm), number of leaves, leaf area, root and shoot parameters, AGR, RGR, survival percentage (68.0%) and root volume, whereas minimum value of most of the parameters were observed in the season where grafting operation performed in 2nd fortnight of March (T_{16}). Overall the significant and superior results were found in the season where grafting performed in 1st fortnight of November (T_7) might be due to availability of superior conditions in this season like temperature and relative humidity, which are required for sprouting, survival percentage and subsequent growth parameters. Furthermore, these experimental findings are based on only one season data; therefore there is need for further confirmation of the results to minimize sprouting time, higher sprouting and survival percentage and subsequent growth parameters in of guava grafts.

Keywords: Guava, softwood grafting, sprouting, leaf area, survival percentage

Introduction
Guava (*Psidium guajava* L.) belonging to family myrtaceae, is one of the most significant fruit crops cultivated in the world, commonly known as 'Apple of tropics' (Menzel 1985) [9]. Taxonomically it is diploid (2n=22) however, aneuploids, triploids and synthetic triploids (2n=33) are also found. It is basically tropical fruit can be grown in subtropical regions due to their wider adaptability. In India, it can be cultivated as tropical and subtropical climate. It ranks 5th after mango, banana, papaya, and citrus. It is principally cultivated in India, Indonesia, Mexico, China, Pakistan, Brazil, Malawi, Thailand, Bangladesh and Egypt with the maximum production of guava (Anon, 2020). India ranks first in guava production all over the world and plays important role in fruit economy of country. In India, area under guava during 2021-22 was 307 thousand ha with annual production were 4516 thousand MT (Anon, 2022). Uttar Pradesh is major guava producing state in India followed by Madhya Pradesh, Bihar, Andhra Pradesh, Haryana, Punjab, West Bengal, Chhattisgarh, Gujarat, Maharashtra and Karnataka (Zanje *et al*., 2023) [17]. Allahabad is recognized for production of high quality of guava in India.

In Maharashtra, the area under guava during 2021-22 was 12.92 thousand ha with annual production were 132.57 MT whereas; Solapur, Jalgaon, Nashik, Ahmednagar, Pune, and Osmanabad are the major guava producing districts of Maharashtra.

Both sexual and asexual propagation methods can be used to multiply guava. The sexually propagated guava doesn't give true to type plants whereas asexually propagated guava through stooling, cutting, layering, inarching and grafting guava yields a crop that is true to type and has a short juvenile phase (Mukherjee and Majumdar, 1983) [10]. Softwood grafting is a cheapest, improved and rapid multiplication technique to achieve the objective of enhances productivity of guava fruit industry. In air layering, fibrous root system is occurred while in softwood grafting generally tap root system is occurred and those grafts having tap root system are essential for high density planting, ultra-high density planting and meadow orcharding of guava. While choosing softwood grafting technique in guava for a particular region, time and method of operation should be taken into consideration; as the success of each method varies from region to region due to variation in agro-climatic condition. A method successfully adopted, it vary from place to place due to environmental factor such as temperature and humidity. The time of the grafting operation plays a key role in determining the final survival of the grafts. Softwood grafting provides the planting materials throughout the year with the least possibility of mortality, leading to better and more uniform orchard establishment. This facilitates the commercialization of guava farming for a number of farmers. The modern technologies should be employed for production of quality planting material through well-established commercial nursery, because of the new planting material developed from softwood grafting had potential to produce true-to-type guava nursery plants. Syamal *et al*. (2013) [16] stated that when guava varieties Allahabad Safeda and L-49 when grafted, they provided the highest rate of grafts survival. Many factors, including compatibility of scion variety and grafting time, play a major role in the final survival of grafts. The dwarfing rootstock which controlled the tree size in high density planting and these rootstocks can be used in softwood grafting to achieve the tree dwarfing effect, which cannot be achieved through other techniques and also the wilt can be managed by using resistant rootstock with the help of softwood grafting only. Konkan region falls under hot and humid climatic condition which ultimately affected the success rate of softwood grafting. Its need to know the actual season for softwood grafting in Konkan region of Maharashtra. In the view of the above context, the study was undertaken to find out the appropriate season to achieve maximum success rate of grafts and final survival percentage in guava grafting.

Materials and Methods

Field experiment was carried out at College of Horticulture, Dr. BSKKV., Dapoli, Dist. Ratnagiri in the year 2022-2023 to find out the appropriate season of softwood grafting for minimized the days to sprouting, higher grafts success percentage, final survival percentage and subsequent growth of guava **(***Psidium guajava* L.**)** grafts under Konkan agro-climatic region. Experimental site was situated on 17º 45' North latitude and 73º 12' East longitude with an altitude of 240 meter above sea level and the region is characterized by a warm and humid tropical climate (Zanje *et al*., 2023) [17]. Soils of this region are lateritic, deep, porous and acidic in reaction having pH range of 5.6-6.5. Average minimum and maximum temperature are 18.5 °C and 30 °C respectively. The average annual rainfall is 3500-4000 mm distributed mainly during South West monsoon from June to October. Experiment was laid out in randomized block design with sixteen treatments *viz*., T_1:Grafting in 1st fortnight of August, T_2:Grafting in 2nd fortnight of August, T_3:Grafting in 1st fortnight of September, T_4:Grafting in 2nd fortnight of September, T_5:Grafting in 1st fortnight of October, T_6:Grafting in 2nd fortnight of October, T_7:Grafting in 1st fortnight of November, T_8:Grafting in 2nd fortnight of November, T_9:Grafting in 1st fortnight of December, T_{10}:Grafting in 2nd fortnight of December, T_{11}:Grafting in 1st fortnight of January, T_{12}:Grafting in 2nd fortnight of January, T_{13}:Grafting in 1st fortnight of February, T_{14}:Grafting in 2nd fortnight of February, T_{15}:Grafting in 1st fortnight of March, T_{16}:Grafting in 2nd fortnight of March which were replicated 2 times. Grafting was done by using scion of L-49 on local guava rootstocks which were healthy seedlings of about 7 month old were selected as a grafting purpose and the grafting operation was undertaken from 1st forth night of August and continued up to March. The plant protection schedule was followed in order to prevent the infection of insect, pests and diseases. The observations including sprouting parameters and subsequent growth parameters were recorded at 30, 60 and 90 days after grafting operation.

Sprouting percentage

It was calculated by using the formula given below (Sonawane *et al.*, 2012) [15].

$$\text{Sprouting percentage (\%)} = \frac{\text{No. of grafts sprouted}}{\text{Total number of grafts tied}} \text{x} 100$$

Absolute growth rate

Absolute growth rate was calculated with the help of formula given by Radford (1967) [12].

$$\text{AGR} = \frac{(H_2) - (H_1)}{(t_2) - (t_1)}$$

Where, H_2 and H_1 refer as height of each graft at time t_2 and t_1 respectively in days.

Relative growth rate

Relative growth rate was calculated with the help of formula given by Briggs *et al*. (1920) [3].

$$\text{RGR} = \frac{\text{Log}H_2 - \text{Log}H_1}{(D_2) - (D_1)}$$

Where, H_2 and H_1 represent the height per graft at D_2 and D_1 days respectively.

Survival percentage

The survival percentage were recorded as daily intervals from the date of softwood grafting to 90 days after grafting, recorded accordingly and it was calculated using the following formula (Sonawane *et al.*, 2012) [15].

$$\text{Survival percentage (\%)} = \frac{\text{Number of grafts survived}}{\text{Total number of grafts tied}} \text{x} 100$$

Root: Shoot ratio

Root: Shoot ratio is calculated by recording dry weight of root and shoot by using following formula (Sonawane *et al.*, 2012) [15].

$$\text{Root: shoot ratio} = \frac{\text{Dry weight of root}}{\text{Dry weight of shoot}}$$

Statistical analysis

The collected experimental data on various parameters during course of study were statistically analyzed with the help of randomized block design method suggested by Panse and Sukhatme (1995) [11] and mean were taken for the comparison and interpretation of results.

Results and Discussion

Days required to bud sprouting

Data on days required for bud sprouting of guava grafts were significantly influenced by different season of softwood grafting (Table 1) and the minimum days (16.0 days) required for bud sprouting were recorded in T_7 which was at par with T_8 (17.0 days) and T_9 (17.0 days). However, the maximum days (24.0 days) required for bud sprouting were in T_{16}. Minimum days to bud sprouting after grafting (T_7) might be due to availability of ideal environmental conditions which helped in better contact of cambial layer and good vascular connection between stock and scion that resulted in early callus formation and stimulate the cambium activity and ultimately affected the early emergence of sprouts. These results are in conformity with the findings of Kholia *et al.* (2017) [6] in guava.

Sprouting pattern

Data on sprouting pattern percentage of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 1). At 14 DAG, the maximum sprouting pattern (10.5%) were recorded in T_7 and which was at par with T_9 (9.0%), T_6 (9.0%) and T_{10} (8.5%) while, the minimum value were in T_{15} and T_{16}. At 21 DAG, the maximum sprouting pattern (20.5%) were recorded in T_7 and which was at par with T_9 (20.5%) and T_{10} (20.0%) whereas, the minimum pattern (6.0%) were in T_{16}. At 28 DAG, the maximum sprouting pattern (26.5%) were recorded in T_7 and which was at par with T_9 (25.0%), T_8 (24.5%) and T_{10} (24.5%), while the minimum pattern (10.0%) were recorded in T_{16}. At 35 DAG, the maximum sprouting pattern (30.0%) were recorded in T_7 and which was at par with T_9 (30.0%), T_8 (28.5%) and T_{10} (27.0%) whereas, the minimum pattern (14.5%) were in T_{16}. At 42 DAG, the maximum sprouting pattern (34.5%) were recorded in T_9 and which was at par with T_8 (31.0%), T_7 (34.5%) and T_{10} (32.0%) whereas, the minimum sprouting pattern (17.0%) were recorded in the T_1. At 49 DAG, the maximum sprouting pattern (36.5%) were recorded in T_7 and which was at par with treatments T_9 (36.5%), T_{10} (35.0%) and T_8 (32.5%) whereas, the minimum sprouting pattern (17.0%) were recorded in the T_1. The effect of season had profound effect on sprouting pattern percentage of guava grafts and it depends on the activity of meristematic cells. Higher is the healing capacity of cells higher is the graft success. Maximum sprouting pattern percentage were found in the T_7 this was might be due to humid climatic environment that played an important role in early and quick contact of cambium layer of scion and rootstock resulting in easy tissue formation and subsequent growth and development. A correlated finding were also reported by Sonawane *et al.* (2012) [15] in carambola, Kholia *et al.* (2017) [6] in guava and Mane *et al.* (2019) [7] in champaca.

Sprouting percentage

Data on sprouting percentage of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 1). Maximum sprouting percentage (73.0%) were recorded in T_7 and which was at par with T_{10} (70.0%) whereas, the minimum sprouting (34.0%) were recorded in T_1. The effect of season had profound effect on sprouting percentage of guava grafts and it depends on the activity of meristematic cells. Higher is the healing capacity of cells higher is the graft success. The maximum sprouting percentage were found in the T_7 this was might be due to humid climatic environment that played an important role in early and quick contact of cambium layer of scion and rootstock resulting in easy tissue formation and subsequent growth and development. A correlated finding were also reported by Sonawane *et al.* (2012) [15] in carambola, Kholia *et al.* (2017) [6] in guava and Mane *et al.* (2019) [7] in champaca.

Graft height

Data on graft height of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 2). At 30 DAG, the highest graft heights (52.72 cm) was recorded in T_7 and which was at par with T_9 (51.30 cm). However, the minimum graft height (41.62 cm) was in T_{16}. At 60 DAG, the highest graft height (57.59 cm) was recorded in T_7 and which was at par with T_8 (56.72 cm). However, the minimum graft height (45.89 cm) was in T_{16}. At 90 DAG, the maximum graft height (63.58 cm) was recorded in T_7 and which was at par with T_8 (62.85 cm), while the minimum graft height (49.73 cm) was in T_{16}. Maximum graft height of guava grafts was found in T_7 this was might be due to the photosynthates produced by the leaves that helps the graft union to heal by increasing cambial activities. Meanwhile, the roots also get well-nourished and a strong root system might absorb more nutrients from the soil, which in turn increases height. The similar findings were also reported by Rani *et al.* (2015) [13] in guava and Manga and Jholgikar (2017) [8] in guava.

Stem girth

Data on stem girth of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 2). At 30 DAG, the highest stem girth (8.96 mm) was recorded in T_7 and which was at par with T_8 (8.92 mm). However, the minimum stem girth (5.57 mm) was in T_{16}. At 60 DAG, the maximum stem girth (9.26 mm) was noticed in T_7 and which was at par with T_8 (9.04 mm). However, the minimum stem girth (5.82 mm) was recorded in T_{16}. At 90 DAG, the maximum stem girth (9.60 mm) was recorded in T_7 and minimum stem girth (6.0 mm) was in T_{16}. The maximum stem girth of guava grafts was found in the T_7 this was might be due to the favourable climatic conditions that increased photosynthetic activities and translocated the food materials towards the stem which resulted in increased in cell division and cell elongation at stem, thereby increased girth of guava grafts. The analogues findings were also reported by Manga and Jholgikar (2017) [8] in guava, Mane *et al.* (2019) [7] in champaca and Ruchita *et al.* (2022) [14] in elite jamun.

Number of shoots

Data shown in Table 2 indicated that the number of shoots of guava grafts varied significantly among the different softwood grafting treatments at 60 and 90 DAG, while non-significant data where observed at 30 DAG. At 30 DAG, the maximum shoots (1.25 nos.) were recorded in the T_7 while the minimum shoots (0.5 nos.) were in T_{16}. At 60 DAG, significantly the maximum shoots (3.0 nos.) were recorded in T_7 and which was at par with T_8 (3.0 nos.), T_9 (3.0 nos.), T_{10} (3.0 nos.), T_4 (2.5 nos.) and T_5 (2.5 nos.). However, the minimum shoots (1.0) were in $T_{16.}$ At 90 DAG, significantly the maximum shoots (4.0 nos.) were recorded in T_7 and which was at par with T_8 (4.0 nos.) and T_9 (4.0 nos.) while the minimum shoots (1.0) were in T_{16}. Maximum shoots of guava grafts were found in the treatment T_7 this was might be due to availability favourable climatic condition that are important for grafts to perform their activities. The optimum availability of morning and evening relative humidity ranged from 54-91% and maximum and minimum temperature ranged from 15-31ºC during this season that might be affected the new emergence of sprouts to the grafts. The correlated findings were also reported by Manga and Jholgikar (2017) [8] in guava and Ruchita *et al.* (2022) [14] in elite jamun.

Shoots length

Data on shoots length of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 3). At 30 DAG, the highest shoots length (0.94 cm) was recorded in T_7 and which was at par with T_8 (0.91cm) whereas the lowest shoots length (0.11cm) was in T_{16}. At 60 DAG, the highest shoots length (2.06 cm) was recorded in T_7 while the lowest shoots length (0.54 cm) was in $T_{16.}$ At 90 DAG, the highest shoots length (4.95 cm) was recorded in T_7 and which was at par with T_8 (4.91cm) while the lowest shoots length (2.59 cm) was in $T_{16.}$ The maximum shoots length of guava grafts were found in the T_7 this was might be due to favourable environmental condition that increases the metabolic activities and action of carbohydrates in shoot portion which leads to extension of growth of shoot and increased in length of shoots. A correlated findings were also reported by Khandekar *et al.* (2006) [5] in nutmeg, Sonawane *et al.* (2012) [15] in carambola and Manga and Jholgikar (2017) [8] in guava.

Number of leaves: Data shown in Table 3 indicated that the numbers of leaves of guava grafts varied significantly among the different softwood grafting treatments. At 30 DAG, the maximum leaves (11.5 nos.) were recorded in T_7 and which was at par with T_8 (11.5 nos.), T_9 (11.5 nos.) and T_{10} (10.5 nos.). However, the minimum leaves (2.5 nos.) were recorded in $T_{16.}$ At 60 DAG, the maximum leaves (14.5 nos.) were recorded in T_7 followed by T_8 (13.5 nos.) and the minimum leaves (5.5 nos.) were in $T_{16.}$ At 90 DAG, the maximum leaves (20.5 nos.) were recorded in T_7 and which was at par with T_8 (19.5) while the minimum leaves (7.5 nos.) were in $T_{16.}$ The maximum numbers of leaves of guava grafts were found in the treatment T_7 this was might be due to the optimum environmental condition that causes increasing the activity of cell and early sprouting which are further responsible for the development of more number of leaves. These results are in conformity with the results of Rani *et al.* (2015) [13] in guava, Manga and Jholgikar (2017) [8] in guava and Ruchita *et al.* (2022) [14] in elite jamun.

Leaf area

Data on leaf area of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 3). At 90 DAG, the maximum leaf area (38.25 cm²) was recorded in T_7 and the minimum leaf area (24.51 cm²) was recorded in $T_{16.}$ The maximum leaf area of guava grafts were found in T_7 this was might be due to enhanced leaf growth in relation to size of leaf by congenial environmental condition that leads to enhance photosynthetic activities in leaves. This helped in accumulation of carbohydrate, food materials which resulted in increased cell elongation and cell division of leaves. The similar findings were also reported by Khandekar *et al.* (2006) [5] in nutmeg, Rani *et al.* (2015) [13] in guava and Manga and Jholgikar (2017) [8] in guava.

Absolute growth rate

Data depicted in Fig. 1 indicated that during 30-60 DAG, the highest absolute growth rate (0.1998 cm/day) was recorded in the T_8 (Grafting in 2nd fortnight of November) while the lowest absolute growth rate (0.0835cm/day) was in T_{14}. During 60-90 DAG, the highest absolute growth rate (0.2348 cm/day) was recorded in T_{10} while lowest absolute growth rate (0.056 cm/day) was in $T_{3.}$ The maximum absolute growth rate of guava grafts was found in the T_{10} this was might be due to the photosynthates produced by the leaves that helps the graft union to heal by increasing cambial activities. Meanwhile, the roots also gets well-nourished and a strong root system might absorb more nutrients from the soil, which in turn increases height of grafts that causes improving absolute growth rate per unit time. The similar findings are in conformity with the results of Manga and Jholgikar (2017) [8] in guava and Mane *et al.* (2019) [7] in Champaca.

Relative growth rate

Data depicted in Fig. 2 indicated that during 30-60 DAG, the maximum relative growth rate (0.0037cm/cm/day) was recorded in T_8 (Grafting in 2nd fortnight of November). However, the minimum relative growth rate (0.0017cm/cm/day) was in T_{14}. During 60-90 DAG, the highest relative growth rate (0.0041cm/cm/day) was recorded in T_5 and the lowest relative growth rate (0.0011 cm/cm/day) was in $T_{3.}$ The maximum relative growth rate of guava grafts was found in the T_5 this was might be due to availability of favourable climatic condition that increased the metabolic activities, resulted in growth and development of plant. Meanwhile, the roots also gets well-nourished and a strong root system might absorb more nutrients from the soil, which in turn increases height of grafts that causes improving relative growth rate per unit time. The analogous findings were also reported by Manga and Jholgikar (2017) [8] in guava and Mane *et al.* (2019) [7] in champaca.

Survival percentage

Data shown in Table 4 indicated that the final survival percentage of guava grafts varied significantly among the different softwood grafting treatments. At 90 DAG, the maximum survival percentage (68.0%) were recorded in T_7 whereas, minimum survival percentage (23.0%) were recorded in T_{16}. The maximum survival percentage of guava grafts was found in the T_7 this was might be due to availability of optimum environmental conditions that increased cell activity and nutrient uptake resulted in higher survival rate. There was increased accumulation of carbohydrates and food

material in scion that mobilized for new growth and depends on activity of cambial cells. These results are in conformity with the results of Khandekar *et al.* (2006) [5] in nutmeg, Joshi *et al.* (2014) [4] in guava and Kholia *et al.* (2017) [6] in guava.

Fresh shoots weight

Data on the fresh shoots weight of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 4). At 90 DAG, the maximum fresh shoots weight (36.75 g) of guava grafts were recorded in T_7 followed by T_8 (35.57 g) while, the minimum fresh shoots weight (17.21 g) was recorded in $T_{16.}$ The maximum fresh shoots weight of guava grafts was found in T_7 this was might be due to optimum environmental conditions in that season which attributed to increase graft height, graft girth, number of leaves, number of shoots and leaf area that cause fast growth of graft which ultimately resulted into maximum fresh shoot weight of guava grafts. The correlated findings were also reported by Manga and Jholgikar (2017) [8] in guava and Mane *et al.* (2019) [7] in champaca.

Dry shoots weight

Data on the dry shoots weight of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 4). At 90 DAG, the maximum dry shoots weight (25.73 g) of guava grafts were recorded in T_7 while, the minimum dry shoots weight (12.82 g) were in T_{16}. The maximum dry shoots weight of guava grafts was found in the T_7 this was might be due to optimum environmental conditions in that season which attributed to increase graft height, graft girth, number of leaves, number of shoots and leaf area that cause fast growth of graft which ultimately resulted into maximum dry shoot weight of guava grafts. The similar findings were also reported by Joshi *et al.* (2014) [4] in guava, Manga and Jholgikar (2017) [8] in guava and Mane *et al.* (2019) [7] in champaca.

Fresh roots weight

Data on the fresh roots weight of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 4). At 90 DAG, the maximum fresh roots weight (18.74 g) of guava grafts were recorded in T_7 followed by T_8 (17.94 g) while, minimum fresh root weight (8.45 g) was recorded in $T_{16.}$ The maximum fresh roots weight of guava grafts was found in the T_7 this was might be due to the fact that, favourable environment increases shoot and root growth. Increased activities in root portion causes elongation of roots ultimately increased fresh root weight of guava grafts. The similar findings were also reported by Joshi *et al.* (2014) [4] in guava, Manga and Jholgikar (2017) [8] in guava and Mane *et al.* (2019) [7] in champaca.

Dry roots weight

Data on the dry root weight of guava grafts were significantly influenced by different season of softwood grafting in guava (Table 4). At 90 DAG, the maximum dry root weight (15.54 g) of guava grafts were recorded in T_7 while, the minimum dry root weight (6.27 g) were in $T_{16.}$ The maximum dry roots weight of guava grafts was found in T_7 this was might be due to the fact that, favourable environment increases shoot and root growth. Increased activities in root portion causes elongation of roots ultimately increased dry root weight of guava grafts. The similar findings were also reported by Joshi *et al.* (2014) [4] in guava, Manga and Jholgikar (2017) [8] in guava and Mane *et al.* (2019) [7] in champaca.

Root: shoot ratio

Data shown in Table 4 indicated that the root:shoot ratio of guava grafts varied significantly among the different softwood grafting treatments. At 90 DAG, the maximum root:shoot ratio (0.6) of guava grafts were recorded in T_7 and which was at par with T_{10} (0.59), T_{11} (0.59) and T_6 (0.59) whereas, minimum root: shoot ratio (0.44) was recorded in $T_{3.}$ The maximum root: shoot ratio of guava grafts was found in the treatment T_7 this was might be due to the fact that, favourable environment increases shoot and root growth. Increased activities in root portion causes elongation of roots ultimately increased root: shoot ratio of guava grafts. The similar findings were also reported by Joshi *et al.* (2014) [4] in guava and Manga and Jholgikar (2017) [8] in guava.

Root volume

Data shown in Table 4 indicated that the root volume of guava grafts varied significantly among the different softwood grafting treatments. At 90 DAG, the maximum root volume (4.13 cc) of guava grafts were recorded in T_7 followed by T_8 (3.91 cc) while, minimum root volume (1.40 cc) was in $T_{16.}$ The maximum root volume of guava grafts was found in T_7 this was might be due to the fact that, favourable environment increases shoot and root growth. Increased activities in root portion causes elongation of roots ultimately increased root volume of guava grafts. The similar findings were also reported by Joshi *et al.* (2014) [4] in guava and Manga and Jholgikar (2017) [8] in guava.

Table 1: Effect of season of softwood grafting on days to sprouting, sprouting pattern and sprouting percentage of guava grafts

Treatment details	Days required for bud sprouting (nos.)	Sprouting pattern (%)						Sprouting percentage (%)
		Number of sprouts of grafts in day's interval						
		14 DAG	21 DAG	28 DAG	35 DAG	42 DAG	49 DAG	
T_1:Grafting in 1st fortnight of August	23.0	3.50	10.50	13.00	15.50	17.00	17.00	34.0
T_2:Grafting in 2nd fortnight of August	22.0	2.50	9.00	15.50	18.50	21.00	23.50	47.0
T_3:Grafting in 1st fortnight of September	22.0	4.00	13.00	15.50	18.50	23.50	24.50	49.0
T_4:Grafting in 2nd fortnight of September	21.0	6.50	10.50	15.00	17.50	19.50	19.50	39.0
T_5:Grafting in 1st fortnight of October	18.0	5.50	10.50	18.00	23.00	24.00	26.50	53.0
T_6:Grafting in 2nd fortnight of October	18.0	9.00	16.00	22.00	23.50	26.50	31.00	62.0
T_7:Grafting in 1st fortnight of November	16.0	10.50	20.50	26.50	30.00	33.50	36.50	73.0
T_8:Grafting in 2nd fortnight of November	17.0	7.50	16.50	24.50	28.50	31.00	32.50	65.0
T_9:Grafting in 1st fortnight of December	17.0	9.00	20.50	25.50	30.00	34.50	36.50	72.0
T_{10}:Grafting in 2ndfortnight of December	18.0	8.50	20.00	24.50	27.00	32.00	35.00	70.0
T_{11}:Grafting in 1st fortnight of January	19.0	7.00	13.50	18.50	23.00	26.50	26.50	53.0
T_{12}:Grafting in 2nd fortnight of January	19.0	5.50	14.50	22.00	23.00	26.50	30.00	60.0

T_{13}:Grafting in 1st fortnight of February	20.0	3.50	11.00	18.00	20.50	21.50	24.50	49.0
T_{14}:Grafting in 2nd fortnight of February	20.0	3.00	12.00	15.00	17.00	20.50	21.50	43.0
T_{15}:Grafting in 1st fortnight of March	23.0	0.00	8.50	13.00	16.50	19.50	22.50	45.0
T_{16}:Grafting in 2nd fortnight of March	24.0	0.00	6.00	10.00	14.50	18.50	19.00	38.0
S.Em±	0.34	2.15	2.05	1.21	1.55	1.33	1.33	2.65
CD (P=0.05)	1.03	6.47	6.18	3.64	4.66	4.01	4.00	7.99

Table 2: Effect of season of softwood grafting on graft height, stem girth and number of shoots of guava grafts

Treatment details	Graft height (cm)			Stem girth (mm)			Number of shoots (nos.)		
	Days after grafting (DAG)			Days after grafting (DAG)			Days after grafting (DAG)		
	30	60	90	30	60	90	30	60	90
T_1:Grafting in 1st fortnight of August	43.86	47.81	51.55	6.07	6.26	6.56	1.00	1.50	2.50
T_2:Grafting in 2nd fortnight of August	45.13	48.16	52.72	6.58	6.77	7.11	1.00	1.50	2.50
T_3:Grafting in 1st fortnight of September	44.90	48.99	50.67	7.37	7.48	7.81	1.00	1.50	2.50
T_4:Grafting in 2nd fortnight of September	46.00	49.47	54.86	7.50	7.66	8.03	0.75	2.50	2.50
T_5:Grafting in 1st fortnight of October	48.73	52.77	59.80	8.51	8.66	9.02	1.00	2.50	2.50
T_6:Grafting in 2nd fortnight of October	49.77	53.92	60.77	8.60	8.79	9.11	1.00	2.00	3.00
T_7:Grafting in 1st fortnight of November	52.72	57.59	63.58	8.96	9.26	9.60	1.25	3.00	4.00
T_8:Grafting in 2nd fortnight of November	50.57	56.72	62.85	8.92	9.04	9.17	1.00	3.00	4.00
T_9:Grafting in 1st fortnight of December	51.30	54.96	61.67	8.82	9.07	9.18	1.25	3.00	4.00
T_{10}:Grafting in 2nd fortnight of December	49.82	53.68	60.72	8.63	8.84	8.92	1.00	3.00	3.50
T_{11}:Grafting in 1st fortnight of January	47.19	52.13	58.00	8.28	8.50	8.80	1.00	2.00	2.50
T_{12}:Grafting in 2nd fortnight of January	46.99	50.40	56.79	8.10	8.30	8.70	1.00	2.00	2.50
T_{13}:Grafting in 1st fortnight of February	47.72	50.90	56.81	7.93	8.30	8.58	1.00	2.00	2.50
T_{14}:Grafting in 2nd fortnight of February	47.25	49.76	56.28	7.81	7.99	8.17	0.75	1.50	2.50
T_{15}:Grafting in 1st fortnight of March	43.06	46.85	51.00	5.93	6.05	6.37	0.50	1.00	1.50
T_{16}:Grafting in 2nd fortnight of March	41.62	45.89	49.73	5.57	5.82	6.00	0.50	1.00	1.50
S.Em±	0.48	0.54	0.51	0.04	0.07	0.05	0.23	0.29	0.40
CD (P=0.05)	1.45	1.62	1.52	0.13	0.20	0.17	0.70	0.87	1.22

Table 3: Effect of season of softwood grafting on shoot length, number of leaves and leaf area of guava grafts

Treatment details	Shoot length (cm)			Number of leaves (nos.)			Leaf area (cm^2)
	Days after grafting (DAG)			Days after grafting (DAG)			Days after grafting (DAG)
	30	60	90	30	60	90	90
T_1:Grafting in 1st fortnight of August	0.22	0.74	2.94	3.50	5.50	10.50	27.47
T_2:Grafting in 2nd fortnight of August	0.27	0.79	3.11	4.50	6.50	11.50	27.76
T_3:Grafting in 1st fortnight of September	0.30	0.85	3.45	4.50	6.50	12.50	28.48
T_4:Grafting in 2nd fortnight of September	0.37	0.92	3.61	5.50	7.50	12.50	29.38
T_5:Grafting in 1st fortnight of October	0.71	1.78	4.57	9.50	11.50	17.50	36.00
T_6:Grafting in 2nd fortnight of October	0.77	1.83	4.68	9.50	11.50	17.50	36.67
T_7:Grafting in 1st fortnight of November	0.94	2.06	4.95	11.50	14.50	20.50	38.25
T_8:Grafting in 2nd fortnight of November	0.91	1.97	4.91	11.50	13.50	19.50	37.57
T_9:Grafting in 1st fortnight of December	0.89	1.94	4.86	11.50	12.50	17.50	37.06
T_{10}:Grafting in 2nd fortnight of December	0.83	1.87	4.78	10.50	11.50	17.50	37.01
T_{11}:Grafting in 1st fortnight of January	0.65	1.71	4.27	8.00	9.50	15.50	35.39
T_{12}:Grafting in 2nd fortnight of January	0.59	1.57	4.04	6.50	8.50	14.50	33.58
T_{13}:Grafting in 1st fortnight of February	0.51	1.23	3.93	5.00	7.50	13.50	32.46
T_{14}:Grafting in 2nd fortnight of February	0.46	0.99	3.86	5.50	7.50	12.50	30.20
T_{15}:Grafting in 1st fortnight of March	0.16	0.54	2.85	3.50	5.50	8.50	26.44
T_{16}:Grafting in 2nd fortnight of March	0.11	0.54	2.59	2.50	5.50	7.50	24.51
S.Em±	0.01	0.015	0.02	0.61	0.51	0.52	0.13
CD (P=0.05)	0.03	0.05	0.06	1.83	1.54	1.56	0.40

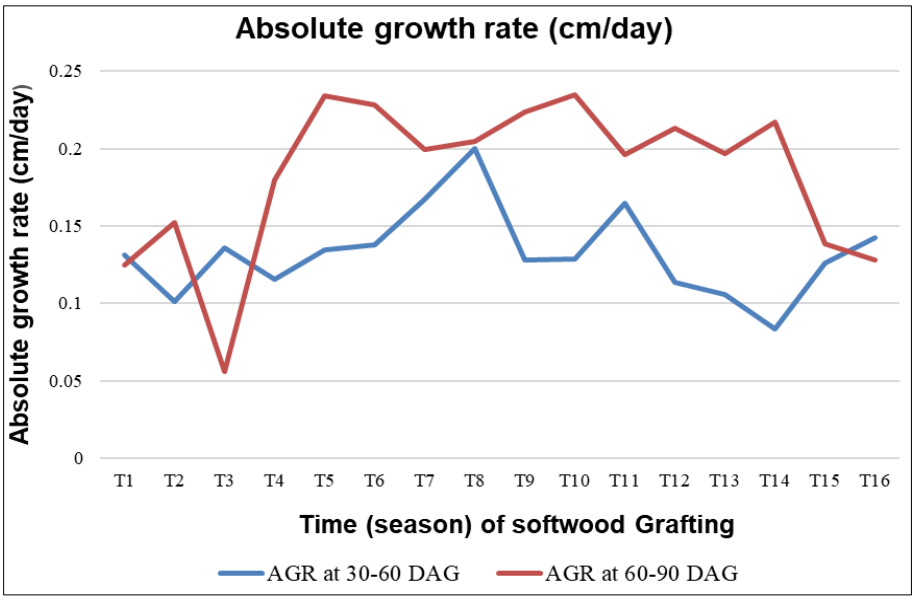

Fig 1: Effect of season of softwood grafting on absolute growth rate of guava grafts

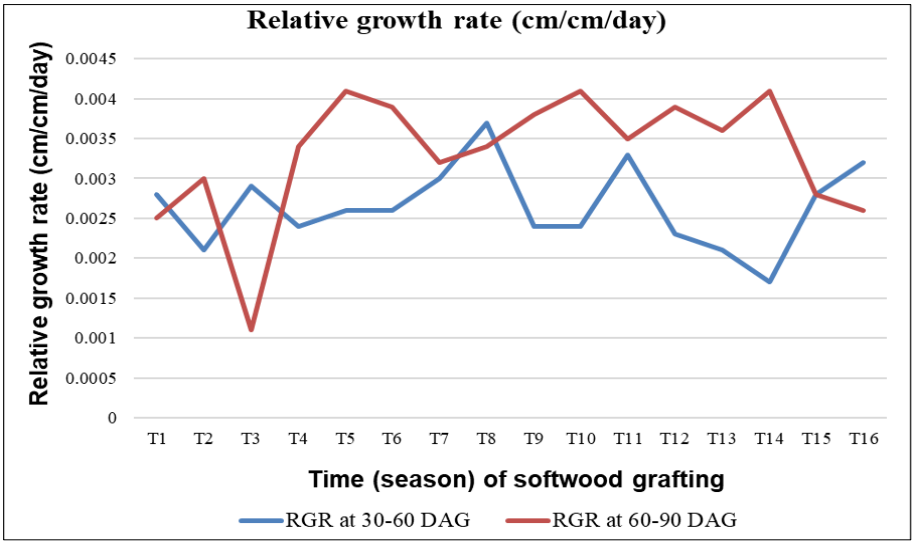

Fig 2: Effect of season of softwood grafting on relative growth rate of guava grafts

Table 4: Effect of season of softwood grafting on survival percentage, shoots and roots weight, root: shoot ratio and root volume of guava grafts

Treatment details	Survival percentage (%)	Fresh weight of shoots (g)	Dry weight of shoots (g)	Fresh weight of roots (g)	Dry weight of roots (g)	Root: shoot ratio	Volume of roots (cc)
	90 DAG	90 DAG	90 DAG	90 DAG	90 DAG		90 DAG
T_1:Grafting in 1st fortnight of August	30.00	19.07	14.75	11.05	7.87	0.53	1.72
T_2:Grafting in 2nd fortnight of August	31.00	19.34	15.57	11.67	8.01	0.51	1.81
T_3:Grafting in 1st fortnight of September	33.00	22.53	19.69	11.00	8.60	0.44	1.90
T_4:Grafting in 2nd fortnight of September	37.00	20.65	15.29	11.50	8.38	0.55	2.06
T_5:Grafting in 1st fortnight of October	53.00	34.70	20.99	13.79	11.84	0.56	3.20
T_6:Grafting in 2nd fortnight of October	56.00	29.82	18.07	13.39	10.74	0.59	3.54
T_7:Grafting in 1st fortnight of November	68.00	36.75	25.73	18.74	15.54	0.60	4.13
T_8:Grafting in 2nd fortnight of November	62.00	35.57	23.70	17.94	13.44	0.57	3.91
T_9:Grafting in 1st fortnight of December	59.00	34.51	20.98	15.79	11.22	0.53	3.49
T_{10}:Grafting in 2nd fortnight of December	57.00	31.80	18.68	14.39	10.96	0.59	3.51
T_{11}:Grafting in 1st fortnight of January	51.00	27.00	16.49	12.68	9.68	0.59	3.07
T_{12}:Grafting in 2nd fortnight of January	47.00	24.86	16.69	12.83	9.60	0.57	2.39
T_{13}:Grafting in 1st fortnight of February	45.00	22.88	16.78	12.31	8.93	0.53	2.29
T_{14}:Grafting in 2nd fortnight of February	42.00	23.64	15.92	12.06	8.50	0.53	2.01
T_{15}:Grafting in 1st fortnight of March	25.00	18.06	13.08	9.00	7.39	0.56	1.61
T_{16}:Grafting in 2nd fortnight of March	23.00	17.21	12.82	8.45	6.27	0.48	1.40
S.Em±	1.41	0.58	0.54	0.63	0.46	0.02	0.09
CD (P=0.05)	4.26	1.74	1.64	1.90	1.39	0.06	0.26

Conclusion

As per the experimental findings, it can be concluded that among different season of softwood grafting in guava, the grafting in 1st fortnight of November (T_7) were found significant and superior for most of the parameters including minimum days to sprouting (16.0 days), maximum sprouting percentage (73.0%), and subsequent growth parameters like graft height (63.58 cm), stem girth (9.6 mm), number of leaves, leaf area, root and shoot parameters, AGR, RGR, survival percentage (68.0%) and root volume, whereas minimum value of most of the parameters were observed in the season where grafting operation performed in 2nd fortnight of March (T_{16}). The superior results in T_7 might be due to availability of superior conditions in this season like temperature and relative humidity, which are required for sprouting, survival percentage and subsequent growth parameters. Furthermore, these experimental findings are based on only one season data; therefore there is need for further confirmation of the results to minimize sprouting time, higher sprouting and survival percentage and subsequent growth parameters in of guava grafts.

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