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Interactive Effects of Grafting Time and Technique on the Sprouting Time and Growth of Guava Grafts (*Psidium guajava* L.)

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ABSTRACT

The present study was conducted during June to September, 2021 at the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Haryana, India to investigate the impact of propagation methods, time, and varieties on the success rate of guava (*Psidium guajava* L.) propagation. The treatments were arranged in a three factorial layout using a Randomized Complete Design with three replications. In the months of June, July, August, and September, two different cultivars (L-49 and Hisar safeda) and four different propagation techniques (Patch budding, T-budding, Wedge grafting, and Inarching) were applied six times each. The results revealed that wedge grafting exhibited the shortest time to sprout (14 days), whereas inarching displayed the longest duration for sprouting (54.33 days). The 2nd fortnight of July and the 1st fortnight of September demonstrated the most favorable time for bud sprouting. Moreover, Hisar Safeda exhibited superior performance compared to L-49 in terms of earlier sprouting and better growth. Therefore, propagation of guava using wedge grafting techniques during the months of July and September can be recommended for the study area and areas with similar agro-ecologies so as to achieve successful grafting within the shortest feasible timeframe. These findings offer crucial insights for agricultural practitioners seeking enhanced propagation techniques and optimal timings, thereby fostering improved guava cultivation practices and augmenting yields in similar agricultural settings.

KEYWORDS: Propagation techniques, rootstock, scion, wedge grafting, inarching

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1. INTRODUCTION

Guava is esteemed for its significant nutritional benefits, which position it as a superfruit. It is a natural source of essential nutrients such as iron, calcium, phosphorus, vitamins A and B, and pectin (Jamieson et al., 2021; Singh, 2005). Furthermore, it contains an impressive array of high-grade antioxidants, including lycopene, carotenoids, tannins, phenols, triterpenes, flavonoids, essential oils, saponins, lectins, and polyphenols (Jimenez-Escrig et al., 2011). Beyond its nutritional value, guava possesses numerous medicinal properties. In traditional medicine, various parts of the guava tree, including its fruits, leaves, and bark, are employed to address a wide range of health issues (Gutiérrez et al., 2002). Multiple countries in Latin America, the Caribbean, India, Africa, and Indonesia have harnessed guava-derived products to treat communicable and non-communicable ailments such as gastrointestinal disorders, hepatic damage, bacterial and fungal infections, fever, rheumatism, respiratory illnesses, cough, diabetes, pain, wounds, mouth ulcers, uterine bleeding, blennorrhagia, menstrual disorders, amenorrhea, and as an emmenagogue (Daswani et al., 2017; Díaz-de-Cerio et al., 2017). These therapeutic effects are attributed to the antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, antihyperglycemic, and antihyperlipidemic properties of various phytochemicals present in *P. guajava* (Kumar et al., 2022). With vitamin C content four times higher than that of oranges, numerous studies have explored the anticancer potential of *P. guajava* against various cancer types, including breast, prostate, blood, colorectal, gynecological, lung, oral, sarcoma, liver, neural, kidney, skin and stomach cancers (Medina et al., 2016).

Guava, with its white-colored, large, faintly fragrant flowers and aromatic evergreen leaves, is also cultivated for ornamental purposes (Ali et al., 2003). It thrives in a wide range of climatic and soil conditions, from sea level to altitudes of 2,100 meters. However, optimal growth conditions include temperatures between 20 and 30°C, annual rainfall ranging from 1,000 to 2,000 mm, well-distributed throughout the year, and soils with good drainage and a pH level of 5 to 7 (Paull et al., 2006; Pereira et al., 2016).

Similar to other plant species nurseries that produce guava seedlings for rootstock grafting face various challenges (Tzatzani et al., 2020). Conventional propagation methods for guava are limited due to its long juvenile growth period and self-incompatibility, typical of woody species (Ali et al., 2003). Moreover, seed multiplication leads to genetically heterogeneous individuals that may grow in the same orchard or separate ones (Martinez-De Lara et al., 2022). As a result, seed propagation is not recommended in commercial orchards to boost productivity. Asexual propagation methods play a crucial role in influencing the vigor, yield, and fruit quality of guava. Guava can be successfully propagated through techniques such as stooling, inarching, layering, cutting, grafting, and budding (Singh and Singh, 2018). Recent research indicates that inarching significantly impacts the survival rate and growth parameters of guava compared to layering and stooling (Kala et al., 2017).

Various grafting techniques, including side grafting, cleft grafting, wedge grafting, T-budding, patch budding, inarching, and splice (whip) grafting, are employed to propagate horticultural crops like guava. The choice of grafting method is influenced by environmental conditions and the specific crop variety. To enhance grafting success rates, it is essential to select suitable rootstocks, time grafting operations according to optimal environmental conditions (Simon et al., 2013), and provide training and expertise to grafting practitioners (Akinnifesi et al., 2018). Additionally, the success of grafting is significantly affected by the chosen grafting technique (Soleimani et al., 2014).

Despite extensive comparative studies on the effectiveness of various propagation techniques and timing conducted in several countries and standardized practices in specific regions (Ghosh and Bera, 2015), such research, especially pertaining to guava production, remains limited in India. Consequently, there is a critical need to standardize propagation techniques and identify the optimal grafting methods to achieve the highest success rates in the shortest possible time for grafted guava varieties. This research endeavor is pivotal in supporting the expansion of guava production not only in the study area but also in similar agro-ecological contexts.

2. MATERIALS AND METHODS

The research was carried out at the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar, in the 2021–22 season, aiming to study the influence of propagation techniques, timing, and varieties on guava's success rate. The experimental site is situated at an elevation of 215 m (750 ft) above mean sea level, with geographical coordinates of 29° 09'N latitude and 75° 42'E longitude. Four methods of vegetative propagation namely, inarching (P_1), shield budding (P_2), patch budding (P_3), and wedge grafting (P_4) were performed during six different propagation times i.e. 2nd fortnight of June (T_1), 1st fortnight of July (T_2), 2nd fortnight of July (T_3), 1st fortnight of August (T_4), 2nd fortnight of August (T_5) and 1st fortnight of September (T_6). Two guava varieties, L-49 (V_1) and Hisar Safeda (V_2) were used as scions. The study employed a factorial arrangement using Randomized Block Design with three replications, resulting in 48 treatment combinations. The graft and bud unions were secured with polyethylene strips and coated with paraffin to ensure an airtight condition and facilitate union. Regular observations were made to determine the days taken for bud sprouting. The date of bud sprouting was recorded when the first sign of bud sprouting was apparent with naked eyes on the grafted scion, and such varying dates were recorded on all experimental grafts per treatment. The average date was calculated for each replication. Following that, the number of days required for bud sprouting was estimated from the grafting date to the average date on which the first bud sprouted vegetative characteristics such as number of sprouted shoots, mean number of leaves and height of grafted/budded plant were measured after 120 days. The collected data underwent statistical analysis using the OPSTAT computer software, employing a three-factor analysis.

3. RESULTS AND DISCUSSION

The perusal of data presented in Table 1 reveals that interaction effect of variety, method and time of propagation on the number of days taken for bud sprouting was found significant. Number of days required for bud sprouting was minimum (14 days) in cultivar L-49 when it was propagated by wedge grafting during the second fortnight of July, which was statistically at par with the variety L-49 propagated by wedge grafting in the first fortnight of September (15.33 days). Whereas, maximum days for bud sprouting were taken by the variety Hisar Safeda, propagated by inarching in the second fortnight of June (54.33 days). During the month of June, when humidity is low and temperature is high, the propagated plants take longer to establish union and thereby there is a delay in the sprouting of shoots (Singh, 2007). On comparing the different methods of propagation, number of days taken for bud sprouting was found least in wedge grafting (19.67 days), followed by patch budding (25.28 days) and shield budding (29.06 days). The lesser time taken by wedge grafted plants to sprout might be due to better contact of cambial layers of stock and scion resulting in early callus formation and initiation of subsequent growth (Chandel et al., 1998). Among the different propagation times, the second fortnight of July (28.54 days) and the first fortnight of September (29.38 days) resulted in significantly lesser days to sprout. The time taken by cultivar Hisar Safeda (30.72 days) to sprout was less than that of L-49 (30.54 days). The results are in striking agreement with the findings of Shyama et al., (2012), who performed wedge grafting in guava with three scion cultivars and reported that the days to sprouting were different for each cultivar.

Table 1: Effect of variety, method and time of propagation on days to sprouting of guava grafts

Time/ Method	L-49							Hisar safeda						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Inarching	53.00	51.67	45.33	46.33	46.00	44.67	47.83	54.33	53.33	46.00	47.33	48.00	46.33	49.22
Wedge grafting	23.33	21.00	14.00	19.00	18.00	15.33	18.44	24.00	23.67	16.67	21.00	20.67	19.33	20.89
Patch budding	28.67	25.33	21.67	23.33	25.00	23.00	24.50	29.67	26.33	24.00	25.33	26.33	24.67	26.06
Shield budding	34.33	31.67	30.67	32.33	32.00	31.67	32.11	0.00	32.33	30.00	32.67	31.00	30.00	26.00
Mean	34.83	32.42	27.92	30.25	30.25	28.67		27.00	33.92	29.17	31.58	31.50	30.08	
Overall mean (V)				30.72							30.54			
Overall mean (T)	30.92		33.17			28.54		30.92		30.88			29.38	
Overall mean (P)		48.53			19.67				25.28			29.06		
CD (p=0.05)		V=NS			T=1.38				P=1.95			V×T×P=3.91		

According to the findings of the study the interaction effect of variety, method, and time of propagation on the number of sprouted shoots was non-significant (Table 2). Propagation in second fortnight of July (3.04) produced significantly higher number of shoots among various times of propagation which was at par with the first fortnight of September (2.88). Comparing different methods of propagation, highest number of shoots were obtained by inarching (5.15) followed by wedge grafting (3.32). There was no discernible difference between the two varieties. Among different propagation times, the second fortnight of July (3.04) and the first fortnight of September (2.88) resulted in maximum number of sprouted shoots, whereas minimum were obtained in second fortnight of June (2.00). The existence of more active buds and stored food materials in the scion, which is linked to better graft union healing,

Table 2: Effect of variety method and time of propagation on number of sprouted shoots of guava grafts

Time/ Method	L-49							Hisar safeda						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Inarching	4.33	4.83	6.00	5.33	5.67	5.67	5.31	3.67	4.67	5.67	5.33	5.33	5.33	5.00
Wedge grafting	3.00	2.67	4.67	3.50	2.67	4.33	3.47	2.00	2.67	4.00	3.67	3.00	3.67	3.17
Patch budding	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shield budding	1.00	1.00	1.00	1.00	1.00	1.00	0.83	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Mean	2.08	2.38	3.17	2.71	2.58	3.00		1.92	2.33	2.92	2.75	2.58	2.75	
Overall mean (V)				2.65							2.54			
Overall mean (T)	2.00		2.35			3.04		2.73		2.58			2.88	
Overall mean (P)		5.15			3.32				1.00			0.92		
CD (p=0.05)		V=N/S			T=0.23				P=0.18			V×T×P=N/S		

may cause the highest number of sprouts in inarching carried out in the second and first fortnights of July and September, respectively. The fact that fewer sprouts appeared in June may be attributed to higher temperatures and poor sap flow in the grafted plants.

The analysis of the present data revealed that the interaction between variety, method, and time of propagation was found to be significant for mean number of leaves on sprouted shoots (Table 3). Maximum number of leaves were found in patch budding performed in second fortnight of July and August in L-49 and Hisar Safeda respectively. Due to the longer length of the sprout, there might be more leaves. On contrary, minimum number of leaves were observed in L-49 propagated in the second fortnight of June by shield

Table 3: Effect of variety, method and time of propagation on mean number of leaves on sprouted shoots of guava grafts

Time/ Method	L-49							Hisar safeda						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Inarching	10.67 (3.40)	12.00 (3.60)	12.00 (3.60)	12.67 (3.70)	12.67 (3.70)	14.00 (3.87)	12.33 (3.64)	7.33 (2.88)	10.67 (3.41)	11.33 (3.51)	10.00 (3.31)	12.33 (3.65)	12.67 (3.70)	10.72 (3.41)
Wedge grafting	10.67 (3.41)	10.00 (3.31)	11.33 (3.51)	12.67 (3.70)	11.33 (3.51)	13.33 (3.78)	11.56 (3.54)	10.00 (3.32)	10.67 (3.41)	11.33 (3.51)	10.67 (3.41)	12.00 (3.61)	11.33 (3.51)	11.00 (3.46)
Patch budding	13.33 (3.78)	14.00 (3.87)	14.67 (3.96)	13.33 (3.78)	14.00 (3.87)	16.67 (4.20)	14.33 (3.91)	11.33 (3.51)	12.67 (3.70)	14.67 (3.96)	13.33 (3.78)	14.00 (3.87)	14.67 (3.96)	13.44 (3.80)
Shield budding	6.67 (2.76)	10.00 (3.31)	8.67 (3.11)	10.67 (3.41)	8.00 (3.00)	10.00 (3.31)	9.00 (3.15)	0 (1.00)	8.67 (3.09)	8.00 (3.00)	8.00 (3.00)	7.33 (2.88)	7.33 (2.88)	6.56 (2.64)
Mean	10.33 (3.34)	11.50 (3.52)	11.67 (3.54)	12.33 (3.65)	11.50 (3.52)	13.50 (3.79)	-	7.17 (2.68)	10.67 (3.40)	11.33 (3.49)	10.50 (3.38)	11.42 (3.50)	11.50 (3.51)	-
Overall mean (V)				11.81 (3.56)							10.43 (3.33)			
Overall mean (T)	8.75 (3.01)		11.08 (3.46)			11.50 (3.52)		11.42 (3.51)		11.46 (3.51)			12.50 (3.65)	
Overall mean (P)		11.53 (3.53)			11.28 (3.50)				13.89 (3.85)			7.78 (2.90)		
CD (p=0.05)		V=0.06			T=0.11				P=0.09			V×T×P=0.32		

*Value in parenthesis denote square root transformation budding (6.67). It may be due to the limited length of the shoot and the immobility of the food source. Propagation in first fortnight of September (12.50) produced significantly higher number of leaves on sprouted shoots among different times of propagation followed by second fortnight of July (11.50). Comparing different methods of propagation, highest number of leaves were obtained by patch budding (13.89) followed by inarching (11.53). Significant variations were observed in mean number of leaves on sprouted shoots in both the cultivars. L-49 had higher number of leaves (11.81) in comparison to Hisar Safeda (10.43). The favorable environmental conditions primarily accelerate the early bud breaking and secondarily influence the maximum leaf flushing as well as the maximum number of leaves due to early healing and graft union formation. The early grafted sapling had the lowest number of leaves per sapling, possibly due to low temperature and relative humidity at the time of graft union formation and leaves emergence. The extreme temperature and unfavorable relative humidity hindered callus cells' differentiation, which ultimately reduced the transport and movement of water and mineral nutrients through xylem and photosynthate from other parts of the sapling to the other (Bhandari et al., 2021). The findings are similar to those of Kaur 2017 who also reported that mango seedlings grafted during the month of July generated the highest number of leaves.

In the present investigation it was revealed that the interaction effect of variety, technique, and propagation time on the height of grafted and budded plants was significant (Table 4). The maximum height was exhibited by the variety Hisar Safeda when it was propagated by inarching in the second fortnight of July (74.83 cm), which was at par with the first fortnight of September (74.77 cm). Minimum plant height was observed in wedge-grafted plants of L49 propagated in the second fortnight of June (34.90 cm), followed by the first fortnight of July (35.84 cm). In comparison to the other methods of propagation, inarching resulted in the maximum plant height (69.16 cm), followed by patch budding (60.48 cm). Among the various propagation times, the second fortnight of July (59.18 cm) and the first fortnight of September (58.57 cm) resulted in taller plants. The height of plants in cultivar Hisar Safeda (58.69 cm) was significantly higher than that of L-49 (54.25 cm). This may be attributed to the genotypic characteristics of the variety. Furthermore, the results also depicted that the plant height of grafted and budded plants was significantly affected by interactions between variety, method, and time of propagation.

Table 4: Effect of variety, method and time of propagation methods on plant height (cm) of guava grafts

Time/ Method	L-49							Hisar safeda						
	T_1	T_2	T_3	T_4	T_5	T_6	Mean	T_1	T_2	T_3	T_4	T_5	T_6	Mean
Inarching	64.87	67.40	71.57	65.43	68.20	66.27	67.29	66.67	70.17	74.83	70.40	69.33	74.77	71.03
Wedge grafting	34.90	35.84	42.50	40.10	39.27	42.40	39.17	38.83	38.03	42.83	41.87	40.77	41.43	40.63
Patch budding	56.50	55.90	58.27	59.23	55.57	59.93	57.57	62.20	62.03	65.33	63.77	60.93	66.10	63.39
Shield budding	40.10	53.33	57.83	53.50	56.83	56.27	52.98	59.17	58.53	60.29	60.60	58.20	61.38	59.70
Mean	49.09	53.12	57.54	54.57	54.97	56.22		56.72	57.19	60.82	59.16	57.31	60.92	
Overall mean (V)				54.25							58.69			
Overall mean (T)	52.90		55.16			59.18			56.86		56.14		58.57	
Overall mean (P)		69.16			39.90				60.48			56.34		
CD (p=0.05)		V=0.87			T=1.50				P=1.23			V×T×P=4.24		

4. CONCLUSION

Both the main and interaction effects of grafting time and technique had significantly influenced days required to bud sprouting, number of sprouted shoots, number of leaves per sprout and height of grafted/ budded plants of guava. The plants grafted using wedge grafting technique in July and September required the minimum time to buds sprouting of the scion whereas maximum growth of grafted guava was obtained by plants propagated by inarching during these months.

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