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Optimizing grafting techniques and timing for enhanced sturdiness, plant spread, and scion: Stock ratio in grafted guava plants

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Abstract
The experiment was undertaken to evaluate the efficacy of different propagation techniques in open field conditions during various time periods. The experimental materials included scion cultivar Hisar Safeda and L-49. Four propagation methods, namely shield budding, patch budding, inarching, and wedge grafting with polycap, were performed on the rootstocks L-49. The results demonstrated significant variations in terms of plant spread (cm), Scion: Stock ratio and Sturdiness Quotient, influenced by the different methods, varieties, times of propagation, and their interaction. The sturdiest plants were obtained by wedge grafting performed during the second fortnight of June.

Keywords: Optimizing grafting techniques, enhanced sturdiness, plant spread, stock ratio, grafted guava

Introduction
Guava (*Psidium guajava* L.), commonly known as the 'Apple of the tropics,' is a member of the Myrtaceae family, which encompasses over 80 genera and 3000 species distributed throughout the tropics and subtropics, mainly in Asia, the Americas, and Australia. Within the genus Psidium, there are more than 150 species of evergreen shrubs, with P. guajava being the most renowned and widely cultivated (Paull and Bittenbender, 2006) [2]. It ranks among the top 50 most well-known tropical and subtropical fruits globally, and alongside mango and mangosteen, it is one of the most extensively grown tropical fruits worldwide. Geographically, guava production is predominantly concentrated in Asian countries, accounting for 74% of the global yield, followed by Africa with 15%, and Latin America and the Caribbean with 11% (Altendorf, 2017) [1].

Various propagation methods, including side grafting, cleft grafting, wedge grafting, T-budding, patch budding, inarching, and splice (whip) grafting, are commonly employed to propagate guava and other horticultural crops. Successful grafting heavily relies on the careful selection of appropriate rootstocks and the precise timing of grafting operations, factors that significantly impact the success rate of the process (Simon *et al*., 2010) [3]. Furthermore, the proficiency and expertise of grafting practitioners also play a pivotal role in achieving favorable grafting outcomes. The choice of propagation technique is equally crucial in determining the level of success attained (Soleimani *et al*., 2010).

Numerous comparative studies have been conducted in different countries to assess the relative efficacy of various propagation techniques and determine standardized practices (Ghosh & Bera, 2015) [4]. Establishing standardized propagation techniques and identifying the ideal period for grafting are essential for the rapid multiplication of guava to enhance national guava production. In this context, investigating the relative efficacy of commonly used propagation techniques (Patch budding, T-budding, Wedge grafting, and Inarching) and standardizing the timing of guava grafting operations to achieve the highest success rate of grafted guava varieties are necessary to support the expansion of guava production in the study area and similar agro-ecologies.

Materials and Methods
The research was conducted at the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar, during 2021-2022. The site is situated in a semi-arid zone with geographical coordinates of 29° 09'N latitude and 75° 42'E longitude, at an elevation of approximately 215 m (750 ft) above mean sea level.

The region experiences minimum and maximum temperatures of 15.4 °C (59.7°F) and 32.3 °C (90.1°F), respectively, with an average annual rainfall of 455 mm. The study aimed to investigate the impact of grafting time and technique on guava's success rate. Four methods of vegetative propagation, namely inarching (P_1), T-budding (P_2), patch budding (P_3), and wedge grafting (P_4), were performed at six different propagation times: 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 experimental design followed a Randomized Block Design (RBD) with three replications, and each treatment consisted of 15 plants using L-49 as rootstock. In total, the study consisted of 48 treatments. Upon reaching pencil thickness, healthy and uniformly-sized scions (15 cm long) from respective mother plant varieties were grafted in the morning using the different propagation techniques. Polyethylene strips were used to secure the graft and bud unions, which were further coated with paraffin to create an airtight condition and promote union. Four leaves were retained below the graft union for all treatments to ensure uniformity.

The study involved observations on five randomly selected plants from each replication to evaluate vegetative characteristics, such as the plant spread (cm), Scion: Stock ratio and Sturdiness Quotient of the grafted plant. The plant spread was determined after 120 days by measuring the distance from one end of the tip of leaf to the other end of leaf tip in N-S and E-W directions with the help of a measuring tape and expressed in centimeters (cm). Scion: Stock ratio was calculated as the ratio of the circumference from the scion to that of the rootstock as suggested by Roose *et al.*, (1989) [5]. The sturdiness quotient (SQ) was calculated as the ratio of plant. height (cm) to root collar diameter (mm) as suggested by Gregorio *et al.*, (2004) [6].

$$\text{Sturdiness-quotient} = \frac{\text{Plant height (cm)}}{\text{Root collar diameter (mm)}} \times 100$$

To meet ANOVA assumptions, the data, including the success percentage of grafts, were transformed using the angular transformation method. Subsequently, a three-factor analysis was conducted using OPSTAT computer statistical software.

Results and Discussion

It is evident from Figure 1 that among the two varieties, the most robust plants were obtained in cultivar L-49 when propagated in the second week of June by wedge grafting (1.66), followed by Hisar Safeda propagated using wedge grafting in the second fortnight of June (1.74). Conversely, the least robust plants were obtained in Hisar Safeda propagated in the second fortnight of August by inarching (3.18). In Figure 2, it is apparent that the scion: stock ratio was higher in plants propagated by wedge grafting in the second fortnight of July (0.84), followed by the second and first fortnight of August (0.82) and September (0.82), respectively, in the cultivar Hisar Safeda. This higher stock: scion ratio might be due to better compatibility between the stock and scion, leading to improved transfer of food material from leaves to other plant parts (Bobade *et al*., 2018) [8]. Conversely, the least scion: stock ratio was obtained in the variety Hisar Safeda, propagated by shield budding in the second fortnight of June (0.46).

Regarding plant spread (N-S), data presented in Table 1 indicated a significant interaction between variety, method, and time of propagation. Maximum plant spread was observed in patch budding conducted in the second fortnight of July (22.43 cm) in L-49, followed by the first fortnight of September (22.10 cm). This larger plant spread in patch budding might be attributed to the extensive area of cambium contact between the stock and scion, leading to increased availability of food material at the union point. On the other hand, the minimum plant spread was observed in Hisar Safeda propagated by shield budding in the first fortnight of July (10.53 cm). Propagation during the first fortnight of September (17.08 cm) resulted in significantly larger plant spread among different propagation times, followed by the second fortnight of July (16.97 cm). Comparing different propagation methods, patch budding (19.06 cm) resulted in more plant spread, followed by inarching (17.38 cm). Significant variations in plant spread were observed between both cultivars, with L-49 exhibiting a significantly larger plant spread (16.55 cm) than Hisar Safeda (14.49 cm). Similar observations were reported by and Rani (2010) [7].

Similarly, as per the data presented in Table 2, the interaction between variety, method, and time of propagation was found to be significant for plant spread (E-W). Maximum plant spread was observed in patch budding performed in the second fortnight of July (25.00 cm) in L-49, followed by the first fortnight of September (24.70 cm). In contrast, the minimum plant spread was observed in Hisar Safeda propagated by shield budding in the first fortnight of July (12.43 cm). Propagation during the first fortnight of September (19.13 cm) resulted in significantly larger plant spread among different propagation times, followed by the second fortnight of July (19.07 cm). Comparing different propagation methods, patch budding (21.12 cm) resulted in more plant spread, followed by inarching (19.47 cm). Significant variations in plant spread were observed between both cultivars, with L-49 exhibiting a significantly larger plant spread (19.16 cm) than Hisar Safeda (16.00 cm). These findings align with previous studies conducted by Rani (2010) [7].

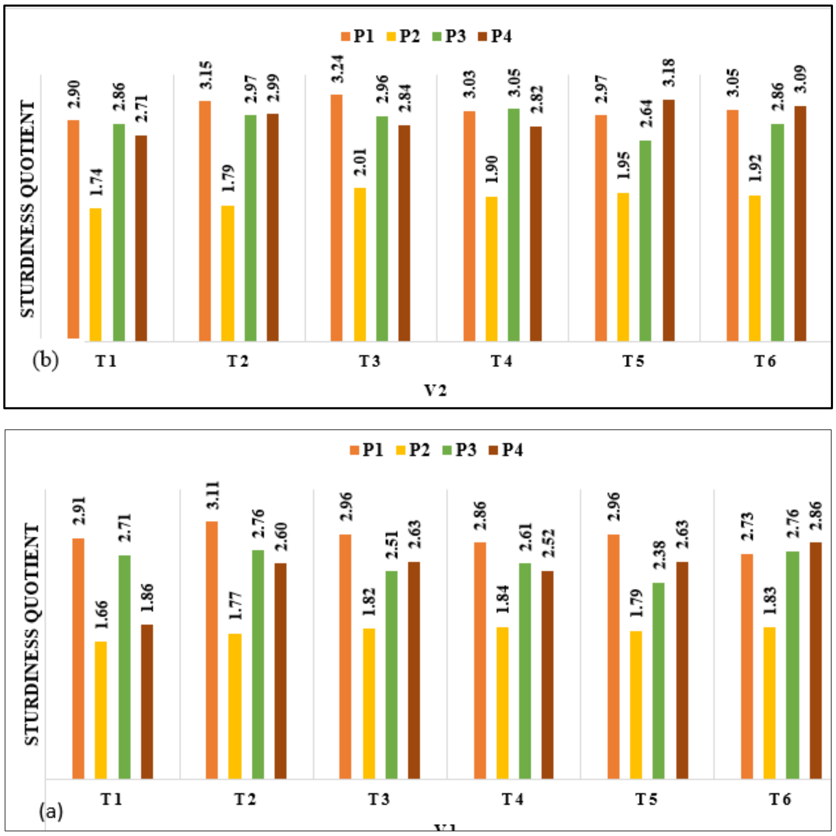

Fig 1: Variation in Sturdiness Quotient with respect to different methods and time of propagation in guava (a) cultivar L-49 and (b) cultivar Hisar Safeda, T_1 – 2nd fortnight of June; T_2 – 1st fortnight of July; T_3 - 2nd fortnight of July; T_4 – 1st fortnight of August; T_5 - 2nd fortnight of August; T_6 – 1st fortnight of September; P_1 – Inarching; P_2 – Wedge Grafting; P_3 – Patch Budding; P_4 – Shield Budding; V1 – L-49; V2 – Hisar Safeda

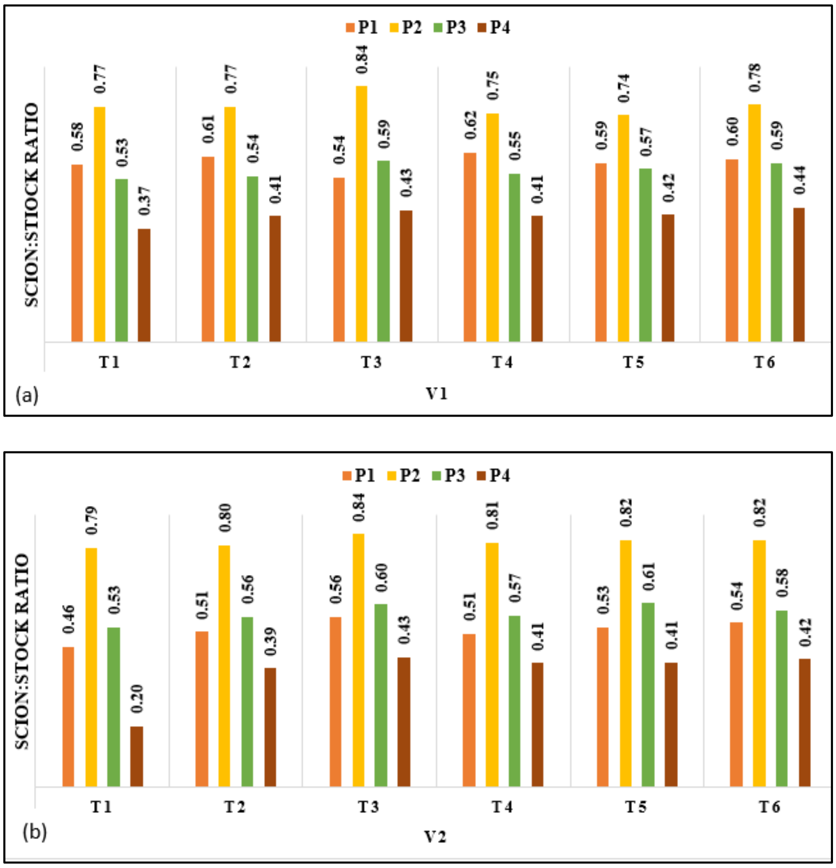

Fig 2: Variation in Scion: Stock Ratio with respect to different methods and time of propagation in guava (a) cultivar L-49 and (b) cultivar Hisar Safeda, T_1 – 2nd fortnight of June; T_2 – 1st fortnight of July; T_3 - 2nd fortnight of July; T_4 – 1st fortnight of August; T_5 - 2nd fortnight of August; T_6 – 1st fortnight of September; P_1 – Inarching ; P_2 – Wedge Grafting; P_3 – Patch Budding; P_4 – Shield Budding; V1 – L-49; V2 – Hisar Safeda

Table 1: Effect of Cultivar, method and time of propagation on plant spread (N-S) (cm) of guava grafts

Variety	L-49							Hisar Safeda						
Time Method	**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	17.13	16.63	18.93	17.67	18.73	20.37	18.24	14.07	16.20	16.60	15.97	17.63	18.63	16.52
Wedge Grafting	12.83	13.13	14.87	13.97	14.60	15.10	14.08	11.73	12.70	14.40	12.70	13.07	14.20	13.13
Patch Budding	18.73	17.87	22.43	19.23	19.63	22.10	20.00	16.90	17.57	19.60	17.40	18.53	18.73	18.12
Shield Budding	12.60	12.77	15.50	13.47	14.00	14.97	13.88	0.00	10.53	13.43	12.37	12.10	12.57	10.17
Mean	15.33	15.10	17.93	16.08	16.74	18.13		10.68	14.25	16.01	14.61	15.33	16.03	
Overall mean (V)	16.55							14.49						
Overall mean (T)	13.00		14.68		16.97			15.35		16.04		17.08		
Overall mean (P)	17.38			13.61				19.06			12.03			
CD (P= 0.05)	V = 0.36			T = 0.63				P = 0.51			V x T x P = 1.80			

T_1 – 2nd fortnight of June; T_2 – 1st fortnight of July; T_3 - 2nd fortnight of July; T_4 – 1st fortnight of August; T_5 - 2nd fortnight of August; T_6 – 1st fortnight of September

Table 2: Effect of variety, method and time of propagation on plant spread (E-W) (cm) of guava grafts

Variety	L-49							Hisar Safeda						
Time Method	**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	19.63	19.10	21.53	20.23	21.37	22.83	20.78	15.83	17.90	18.13	17.60	19.33	20.10	18.15
Wedge Grafting	15.40	15.87	17.63	16.80	17.47	17.77	16.82	13.30	14.03	16.13	14.37	14.73	15.60	14.69
Patch Budding	21.23	20.50	25.00	21.77	22.33	24.70	22.59	18.37	19.13	21.40	18.83	20.20	20.00	19.66
Shield budding	15.03	15.37	17.87	16.20	16.50	17.80	16.46	0.00	12.43	14.87	13.80	13.70	14.27	11.51
Mean	17.83	17.71	20.51	18.75	19.42	20.78	19.16	11.88	15.88	17.63	16.15	16.99	17.49	16.00
Overall mean (V)	19.16							16.00						
Overall mean (T)	14.85		16.79		19.07			17.45		18.20		19.13		
Overall mean (P)	19.47			15.76				21.12			13.99			
CD (P= 0.05)	V = 0.30			T = 0.53				P = 0.43			V x T x P = 1.50			

T_1 – 2nd fortnight of June; T_2 – 1st fortnight of July; T_3 - 2nd fortnight of July; T_4 – 1st fortnight of August; T_5 - 2nd fortnight of August; T_6 – 1st fortnight of September Safeda

Conclusion

Based on the experimental findings, it can be concluded that both the main and interaction effects of grafting time and technique had a significant impact on the plant spread, stock: scion ratio, and sturdiness quotient of grafted guava. Particularly, plants grafted using the wedge grafting technique exhibited greater sturdiness and higher stock: scion ratio.

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