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Guava graft and bud success as affected by different propagation methods, time and varieties

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Abstract
The present research experiment was undertaken at experimental orchard, Department of Horticulture, CCS Haryana Agricultural University during 2021-22 to determine the effect of propagation methods, time and varieties on the success rate of guava (*Psidium guajava* L.). Four propagation techniques (Patch budding, Shield budding, Wedge grafting, and Inarching) were performed across six distinct propagation periods in the months of June, July, August, and September so as to determine their effectiveness on two guava varieties (L-49 and Hisar Safeda). The treatments were arranged in a factorial layout using a Randomized Complete Design with three replications. Patch budding was determined to be the most effective propagation method in every month except the second fortnight of August, in which wedge grafting demonstrated the highest success rate. Among different propagation time, the highest grafting success was observed during the 2nd fortnight of July, followed by 1st fortnight of September. Furthermore, the results revealed that L-49 exhibited superior performance for budding and grafting success as compared to Hisar Safeda. Therefore, propagation of guava using patch budding technique during the 2nd fortnight of July would be more successful for the study area and regions with similar agro-ecologies to increase the success rate of guava propagation.

Keywords: Guava, propagation methods, patch budding, wedge grafting, inarching

Introduction
Guava (*Psidium guajava* L.), known as the 'Apple of the tropics,' is a fruit belonging to the Myrtaceae family. It is a widely cultivated and economically important fruit in India, ranking fourth in terms of area and production after mango, banana, and citrus. However, the proliferation of plants from unreliable sources by nursery operators poses a significant challenge in guava cultivation. This practice leads to a lack of quality planting material and subsequently affects guava production and productivity. While guava has traditionally been propagated through seeds, this method leads to considerable variations in fruit size, shape, and quality. To address this issue, various vegetative propagation techniques such as side grafting, cleft grafting, wedge grafting, shield budding, patch budding, inarching, and splice (whip) grafting are commonly employed. These techniques not only ensure the production of true-to-type plants but also shorten the juvenile phase, making them valuable for guava propagation and the propagation of other horticultural crops. The careful selection of suitable rootstocks and the precise timing of grafting operations are crucial determinants that greatly impact the success rate of grafting. (Simon *et al*. 2010) [7]. Moreover, the proficiency and knowledge of grafting practitioners also play a pivotal role in achieving favorable grafting outcomes (Akinnifesi *et al*. 2008) [1]. Furthermore, the choice of propagation technique plays a crucial role in determining the degree of success achieved (Soleimani *et al*. 2010) [9].
Extensive research has been conducted in various countries to compare and evaluate different methods of propagating guava plants, along with the optimal timing for grafting (Ghosh and Bera 2015) [2]. These studies have been crucial in standardizing propagation techniques and determining the ideal propagation period, which are essential for the rapid multiplication of guava and the overall enhancement of national guava production. In order to support the expansion of guava cultivation in the study area and similar agro-ecological regions, it was imperative to examine the effectiveness of commonly employed propagation techniques such as patch budding, shield budding, wedge grafting, and inarching. Additionally, the aim was to establish a standardized time period for guava grafting operations that would yield the highest success rate in terms of grafted guava varieties.

Materials and Methods

The present research was conducted at the experimental orchard, Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2021-22 to study the effect of propagation technique, time and varieties on the success rate of guava. The experimental site has a typical semiarid climate, with scorching, dry summers and extremely cold winters. In this study, four different 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 including 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 experiment comprised a total of 48 treatment combinations, which were laid out in a factorial arrangement using Randomized Block Design (RBD) with three replications. Each treatment consisted of 15 plants where L-49 was used as a rootstock. As soon as the rootstocks acquired pencil thickness, healthy and uniformly-sized scions (15 cm long) collected from 4- to 5-year-old respective mother plant varieties were grafted in the morning using the different propagation techniques. Following propagation, the graft and bud unions were secured with polyethylene strip and coated with paraffin in order to produce an airtight condition and aid the union of the connected parts. In addition, four leaves were uniformly retained below the graft union for all the treatments to ensure uniformity.

The observations were carried out at regular intervals to assess the success of grafting and budding. To evaluate the vegetative characteristics, including the length and girth of new sprouts, data was collected from five randomly selected plants within each replication after 120 days of budding/grafting. The graft success percentage was calculated by determining the number of successfully sprouted grafts in each treatment and was expressed in percentage. The length and girth of the sprouted shoot of successful grafts was measured using a centimeter scale and vernier calipers, respectively, with both measurements expressed in centimeters. Before analysis, the graft success percentage data were transformed using the angular transformation method to meet the assumptions of ANOVA (Gomez and Gomez 1984). The collected data was then subjected to a three-factor analysis using the OPSTAT computer statistical software.

Results and Discussion

The interaction effect of propagation method, time and varieties yielded a substantial impact on the success rate of guava grafts, indicating a significant interaction effect. According to the presented data (Table 1), the variety L-49, propagated by patch budding in the second fortnight of July, gave the highest success rate (73.33%) compared to the variety Hisar Safeda (60.00%). When the Hisar Safeda variety was propagated by shield budding in the second fortnight of June, no sprouting was observed. Patch budding had a considerably higher success rate than other methods of propagation (43.89%), followed by wedge grafting (36.11). Similarly, shield budding had the lowest success rate (26.11%). It was also recorded that propagation in the second fortnight of July (54.17%) followed by the first fortnight of September (44.17%) resulted in significantly higher success percentage among different propagation times. However, the varietal effect was found non-significant. The findings of this study align with the research conducted by Nowshad *et al.* (2005) [5], which also concluded that patch budding demonstrated higher success rates in guava propagation compared to alternative techniques such as veneer grafting and wedge grafting. Moreover, Negi *et al.* (2010) also reported that the patch budding technique exhibited highest success rate among different techniques performed in aonla. The observed superiority of patch budding over alternative methods in terms of success percentage can be attributed to the increased size and contact area of the bark and cambium tissues within the patch. This larger tissue interface facilitates a more favorable and efficient integration between the stock and scion, resulting in higher graft success rates (Sharma *et al*. 2015) [6].

The analysis of the presented data (Table 2) revealed a significant influence of the variety, propagation method, and timing on the length of new sprouts. Among the different treatments, the maximum shoot length was observed in cultivar L-49 when propagated by patch budding in the second fortnight of July (16.70 cm), which was at par with Hisar Safeda, propagated by patch budding in the second and first fortnights of July (16.07 cm) and September (15.67 cm), respectively. Whereas, minimum shoot length was recorded in L-49 when it was propagated in the second fortnight by shield budding (6.73 cm).

On comparison of different propagation methods, patch budding proved to be most vigorous, producing longer shoots (14.67 cm), followed by inarching (12.85 cm). Among the various propagation times, the second fortnight of July (12.93) and the first fortnight of September (12.89) resulted in considerably longer sprouts. Variety L-49 showed the maximum length of new sprout (12.06 cm), which was significantly longer than that of Hisar Safeda (11.32 cm). The longer sprout length observed can be attributed to the early bud sprouting in plants grafted and budded during July, facilitating a rapid bud and graft union process. The favorable climatic conditions during this period, such as optimal temperature, suitable relative humidity, substantial rainfall, and moist soil, further supported the rapid bud and graft union process (Singh 2007) [8].

According to the findings to the study, girth of the new sprout (Table 3) was influenced by the interaction effect of the variety, method, and time of propagation. Maximum shoot girth was recorded in variety L-49 propagated by patch budding in the second fortnight of July (2.65 cm), which was at par with the variety L-49 propagated by patch budding in the second fortnight of August (2.63 cm). On the contrary, minimum shoot girth was exhibited in L-49 when it was propagated in the second fortnight of June by shield budding (1.02 cm). It was also recorded that patch budding (2.30 cm) yielded the maximum shoot girth, followed by inarching (2.03 cm) in comparison to the other methods of propagation.

Among the various propagation times, the second fortnight of July (2.03 cm) and the first fortnight of September (2.01 cm) resulted in much thicker sprouts.

Considerable variations were observed in the girth of the new sprout in both the cultivars. The girth of sprouted shoot in L-49 (1.89 cm) was higher than that of Hisar Safeda (1.76 cm), although it was not significant. Interactions between variety, method and time of propagation were found to have a significant impact on the girth of sprouted shoots.

Table 1: Effect of variety, method and time of propagation methods on success percentage (%) of guava grafts.

Variety	**L-49**							**Hisar Safeda**						
Time / Method	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean T**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**Mean T**
Inarching	20.00 (26.55)	20.00 (26.55)	53.33 (46.90)	33.33 (35.00)	33.33 (35.00)	46.67 (43.06)	34.44 (35.51)	26.67 (30.78)	20.00 (26.55)	46.67 (43.06)	26.67 (30.78)	33.33 (35.00)	20.00 (26.55)	28.89 (32.12)
Wedge Grafting	20.00 (26.55)	20.00 (26.55)	60.00 (50.75)	40.00 (39.22)	46.67 (43.06)	53.33 (46.90)	40 (38.84)	20.00 (26.55)	26.67 (30.78)	53.33 (46.90)	20.00 (26.55)	26.67 (30.78)	46.67 (43.06)	32.22 (34.10)
Patch Budding	26.67 (30.78)	26.67 (30.78)	73.33 (59.19)	40.00 (39.22)	40.00 (39.22)	66.67 (54.97)	45.56 (42.36)	20.00 (26.55)	20.00 (26.55)	60.00 (50.75)	53.33 (46.90)	46.67 (43.06)	53.33 (46.90)	42.22 (40.12)
T-Budding	20.00 (26.55)	26.67 (30.78)	46.67 (43.06)	20.00 (26.55)	20.00 (26.55)	40.00 (39.22)	28.89 (32.12)	0.00 (0.00)	20.00 (26.55)	40.00 (39.22)	26.67 (30.78)	26.67 (30.78)	26.67 (30.78)	23.33 (26.35)
Mean P	21.67 (27.61)	23.33 (28.67)	58.33 (49.98)	33.33 (35.00)	35.00 (35.96)	51.67 (46.04)	37.22 (37.21)	16.67 (20.97)	21.67 (27.61)	50 (44.98)	31.67 (33.75)	33.33 (34.90)	36.67 (36.82)	31.67 (33.17)
Overall mean (V)	37.22 (37.21)							31.67 (33.17)						
Overall mean (T)	19.17 (24.29)		22.50 (28.14)		54.17 (47.48)			32.50 (34.37)			34.17 (35.43)		44.17 (41.43)	
Overall mean (P)	31.67 (33.82)				36.11 (36.47)			43.89 (41.24)			26.11 (29.23)			
CD (p= 0.05)	V = NS				T = 3.00			P = 2.45			V x T x P = 8.49			

* Values within parentheses denote the angular transformed values

Table 2: Effect of variety, method and time of propagation methods on length (cm) of sprouted shoots 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	12.07	12.93	13.59	12.50	13.07	14.88	13.17	6.90	12.93	14.13	13.60	13.33	14.27	12.53
Wedge Grafting	10.77	11.50	12.87	12.07	11.83	12.30	11.89	9.90	10.90	11.67	11.87	11.93	11.80	11.34
Patch Budding	13.60	13.80	16.70	13.90	14.03	16.40	14.74	12.70	13.50	16.07	14.83	14.87	15.67	14.61
T-Budding	6.73	7.90	9.57	8.77	8.20	9.50	8.44	0.00	7.80	8.87	8.13	7.80	8.27	6.81
Mean	10.79	11.53	13.18	11.81	11.78	13.27	12.06	7.38	11.28	12.68	12.11	11.98	12.50	11.32
Overall mean (V)	12.06								11.32					
Overall mean (T)	9.08			11.41		12.93			11.96			11.88		12.89
Overall mean (P)	12.85					11.62			14.67			7.63		
CD (P= 0.05)	V = 0.28					T = 0.48			P =0.39			V x T x P = 1.36		

Table 3: Effect of variety, method and time of propagation methods on girth (cm) of sprouted shoots 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	1.88	2.06	2.13	1.92	2.14	2.41	2.09	1.12	2.05	2.19	2.13	2.09	2.24	1.97
Wedge Grafting	1.66	1.85	2.04	1.98	1.84	1.88	1.88	1.48	1.72	1.88	1.88	1.86	1.80	1.77
Patch Budding	2.13	2.17	2.65	2.15	2.17	2.63	2.32	1.98	2.09	2.54	2.37	2.34	2.38	2.29
T- Budding	1.02	1.18	1.49	1.33	1.23	1.45	1.29	0.00	1.17	1.31	1.22	1.13	1.28	1.02
Mean	1.67	1.82	2.08	1.84	1.85	2.09	1.89	1.15	1.76	1.98	1.90	1.86	1.93	1.76
Overall mean (V)	1.89					1.76								
Overall mean (T)	1.41		1.79	2.03		1.87			1.85			2.01		
Overall mean (P)	2.03		1.82			2.30			1.15					
CD (P= 0.05)	V = 0.05		T = 0.09			P = 0.07			V x T x P = 0.26					

Conclusion

Based on the obtained experimental results, it can be concluded that patch budding performed during the second and first fortnights of July and September, respectively, yielded the highest grafting success rate and maximum growth in grafted guava plants. Farmers often resort to seed propagation due to the lack of a standardized propagation technique, which results in planting materials that are not true to type and ultimately leads to lower returns on their produce. Therefore, the standardization of patch budding as a propagation method will facilitate the large-scale multiplication of authentic planting material by farmers, consequently increasing productivity. Improved yield and quality will enable farmers to command higher prices in the market, thus enhancing their socio-economic status.

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