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Effect of different rootstocks and time of softwood grafting and microbudding in acid lime

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Abstract

An experiment entitled “Effect of Softwood Grafting and Microbudding in Acid Lime” was conducted during 2025-26 at the Fruit Nursery Unit, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, to evaluate the effect of different rootstocks and grafting time on graft success and vegetative growth of acid lime (*Citrus aurantifolia* Swingle) cv. PDKV Chakradhar. The experiment was laid out in a Factorial Randomized Block Design with two rootstocks and five grafting times. Rough lemon recorded higher graft success (77.33%) and superior vegetative growth than Rangpur lime. Grafting during the first week of January recorded the highest graft success (86.66%) and better growth, while the first week of February showed the lowest performance. The interaction treatment R₁T₃ (Rough lemon in first week of January) recorded the highest graft success (93.33%) and superior vegetative growth. The study indicated that Rough lemon grafted during the first week of January is the most suitable combination for successful softwood grafting of acid lime under Akola conditions.

Keywords: Acid lime, softwood grafting, Rough lemon, graft success, rootstock, grafting time

Introduction

Acid lime (*Citrus aurantifolia* Swingle) is an economically important citrus crop valued for its high vitamin C content, medicinal properties and wide industrial applications. Commercial propagation is mainly carried out through vegetative methods to maintain genetic purity and produce uniform planting material. Among the various propagation techniques, softwood grafting is widely adopted because of its simplicity, rapid multiplication and higher success under favourable environmental conditions (Vijayakumari *et al.*, 2008) [12].

The success of softwood grafting depends largely on rootstock compatibility and the environmental conditions prevailing during grafting. Rootstocks influence graft success, plant vigour and nutrient uptake, while the time of grafting affects cambial activity, callus formation and graft union development (Ahmed Waqar *et al.*, 2006) [1]. Rough lemon and Rangpur lime are commonly used citrus rootstocks due to their vigour and adaptability. Limited information is available on the combined effect of rootstocks and grafting time on softwood grafting of acid lime under Vidarbha conditions. Therefore, the present study was undertaken to evaluate the effect of different rootstocks and grafting time on graft success and vegetative growth of acid lime cv. PDKV Chakradhar and to identify the most suitable combination for quality nursery production.

Materials and Methods

The experiment entitled “Effect of Different Rootstocks and Time of Softwood Grafting in Acid Lime (*Citrus aurantifolia* Swingle) cv. PDKV Chakradhar” was conducted during 2025-26 at the Fruit Nursery Unit, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, with the objective of evaluating the effect of different rootstocks and grafting time on graft success and vegetative growth of acid lime. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with Factor A comprising two rootstocks, viz., R₁ (Rough lemon) and R₂ (Rangpur lime), and Factor B

comprising five grafting times, viz., T₁ (1st week of December), T₂ (3rd week of December), T₃ (1st week of January), T₄ (3rd week of January) and T₅ (1st week of February), resulting in ten treatment combinations replicated three times. Healthy twelve-month-old rootstocks and pencil-sized scion shoots of acid lime cv. PDKV Chakradhar were used for softwood grafting under open nursery conditions. Observations on days to sprouting, graft success, plant height, plant diameter, number of leaves, leaf area, root length, fresh and dry weight of shoots and roots and shoot-to-root ratio were recorded at 180 days after grafting. The data were statistically analyzed using analysis of variance (ANOVA) for FRBD at the 5% level of significance.

Results and Discussion

Days to sprouting

Days to sprouting was significantly influenced by rootstock, grafting time and their interaction (Table 1). Rangpur lime recorded minimum days to sprouting (21.66 days) than Rough lemon (24 days). while the interaction R₁T₃ recorded the minimum days (22.83 days). Early sprouting under favourable conditions agrees with the findings of Muralidhara and Doreyappa Gowda (2019)^[9].

Final graft success (%)

Final graft success was significantly influenced by rootstock, grafting time and their interaction (Table 1). Rough lemon recorded higher graft success (53.33%) than Rangpur lime (40.00%). Grafting during the first week of January (T₃) recorded the highest success (86.66%), which was at par with the third week of December (T₂), while R₁T₃ recorded the maximum graft success (93.33%). The higher success may be attributed to favourable climatic conditions and better stock-scion compatibility, as also reported by Rajamanickam *et al.* (2023)^[10].

Plant height (cm)

Plant height was significantly influenced by rootstock, grafting time and their interaction (Table 2). Rough lemon recorded taller plants (44.40 cm) than Rangpur lime (41.08 cm). Grafting during the first week of January (T₃) produced the maximum plant height (45.30 cm), which was at par with the third week of December (T₂), while the interaction R₁T₃ recorded the tallest plants. The increased plant height may be attributed to better graft compatibility and efficient nutrient translocation. These findings are in agreement with Dubey and Sharma (2012)^[4].

Plant diameter (mm)

Plant diameter was significantly influenced by rootstock, grafting time and their interaction (Table 2). Rough lemon recorded greater stem diameter (5.41 mm) than Rangpur lime. Grafting during the third week of December (T₂) was at par with the first week of January, while the interaction R₁T₂ recorded the maximum stem diameter (5.81mm). Greater stem growth may be attributed to enhanced cambial activity under favourable environmental conditions. Similar observations were reported by Karna *et al.* (2018)^[7].

Number of leaves

The number of leaves was significantly influenced by rootstock, grafting time and their interaction (Table 2).

Rough lemon produced more leaves (20.85) than Rangpur lime. Grafting during the third week of December recorded the highest number of leaves (21.27), which was at par with the first week of January, while the interaction R₁T₂ recorded the maximum number of leaves (23.7). Higher leaf production may be attributed to vigorous vegetative growth and better graft establishment. The present findings are in agreement with Srinivasulu *et al.* (2015)^[11] and Madane *et al.* (2024)^[2].

Leaf area (cm²)

Leaf area was significantly influenced by rootstock, grafting time and their interaction (Table 1). Rough lemon recorded higher leaf area (20.12 cm²) than Rangpur lime. Grafting during the third week of December recorded the maximum leaf area (21.13 cm²), which was at par with the first week of January, while the interaction R₁T₂ recorded the highest leaf area (24.40 cm²). The increased leaf area may be attributed to vigorous vegetative growth. These findings are in agreement with Yadav *et al.* (2012)^[13].

Root length (cm)

Root length varied significantly among the treatments. Rangpur lime recorded significantly greater root length (16.06 cm) than Rough lemon. Among the grafting times, the first week of January recorded the maximum root length (17.38 cm), while the first week of February recorded the minimum. The interaction treatment R₂T₃ recorded the maximum root length (19.10 cm). Better root development under favourable climatic conditions may have contributed to enhanced root growth. These findings are in agreement with Singh *et al.* (2016)^[12], Haque *et al.* (2023)^[6] and El-Taweel *et al.* (2015)^[5].

Fresh weight of shoot (g)

Fresh shoot weight was significantly influenced by rootstock and grafting time. Rough lemon recorded significantly higher fresh shoot weight (8.29 g) than Rangpur lime (6.99 g). The first week of January recorded the maximum fresh shoot weight (9.24 g), whereas the first week of February recorded the minimum. The interaction treatment R₁T₃ recorded the highest fresh shoot weight. Greater shoot biomass may be attributed to vigorous vegetative growth and efficient assimilate translocation. These findings are in agreement with Madane *et al.* (2024)^[2].

Dry weight of shoot (g)

Dry shoot weight was significantly influenced by rootstock, grafting time and their interaction (Table 2). Rough lemon recorded higher dry shoot weight (3.32 g) than Rangpur lime, while grafting during the first week of January recorded the highest value (3.39 g), with the interaction R₁T₃ producing the maximum dry shoot weight (3.88 g). The higher dry shoot weight indicates better graft establishment and plant vigour. These findings are in close agreement with Haque *et al.* (2023)^[6], Chaudhary *et al.* (2022)^[3].

Fresh weight of root (g)

Fresh root weight was significantly affected by rootstock and grafting time. Rangpur lime recorded significantly higher fresh root weight (7.62g) than Rough lemon. The first week of January recorded the highest fresh root weight (8.02 g), whereas the first week of February recorded the lowest. The interaction treatment R₂T₃ recorded the highest fresh root weight. The higher root biomass may be due to

the vigorous rooting ability of Rangpur lime. Similar findings were reported by Yadav *et al.* (2012)^[13].

Dry weight of root (g)

Dry root weight was significantly influenced by rootstock, grafting time and their interaction (Table 4). Rangpur lime recorded higher dry root weight (3.26g) than Rough lemon, while grafting during the first week of January recorded the highest value (3.45 g), with the interaction R₂T₃ producing the maximum dry root weight. The higher dry root weight indicates better root development and dry matter accumulation. Similar observation were reported by Rathore.

Shoot-to-root ratio

The shoot-to-root ratio was significantly influenced by rootstock, grafting time and their interaction (Table 4). Rough lemon recorded a higher shoot-to-root ratio (1.20) than Rangpur lime, while grafting during the first week of January recorded the highest ratio (1.26), with the interaction R₁T₃ producing the maximum value. The higher ratio indicates better assimilate partitioning towards shoot growth and improved vegetative development. These findings are in agreement with Kumar *et al.*, Rajamanickam *et al.* (2023)^[10].

Table 1: Effect of rootstock and time of grafting on Days to sprouting, Final success percentage and leaf area

Treatment	Days to sprouting					Final success percentage					Leaf area (cm ²)				
	Time of grafting					Time of grafting					Time of grafting				
Rootstock	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅
R ₁	27.3	26.5	24.0	27.3	29.0	73.3	86.6	93.3	80.0	53.3	23.5	24.5	18.7	17.6	16.2
R ₂	24.6	23.3	21.6	24.5	24.6	80.0	60.0	80.0	53.3	40	15.3	17.7	16.6	16.2	16.0
Mean	26.0	24.9	22.8	25.9	26.8	76.6	73.3	86.6	66.6	46.6	19.4	21.1	17.6	16.9	16.1
	R	T	R X T			R	T	R X T			R	T	R X T		
F - Test	Sig	Sig	NS			sig	Sig	Sig			Sig	Sig	Sig		
SE (M) _±	0.54	0.86	1.22			1.69	2.67	3.78			0.38	0.60	0.85		
CD at 5%	1.63	2.58	-			5.06	8.01	11.33			1.14	1.80	2.55		

Table 2: Effect of rootstock and time of grafting on plant height and plant diameter and number of leaves

Treatment	Plant Height (cm)					Plant Diameter (mm)					Number of leaves				
	Time of grafting					Time of grafting					Time of grafting				
Rootstock	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅
R ₁	44.2	47.8	50.8	41.1	38.4	5.73	5.81	5.55	4.78	5.19	20.5	23.7	20.3	20.3	19.8
R ₂	45.8	41.2	39.8	42.1	36.5	3.86	4.35	4.25	4.89	3.93	19.07	18.6	18.3	14.6	14.3
Mean	45.0	44.5	45.3	41.6	37.4	4.74	5.07	4.90	4.83	4.56	19.5	21.2	19.3	17.5	17.0
	R	T	R X T			R	T	R X T			R	T	R X T		
F - Test	Sig	Sig	Sig			Sig	Ns	Sig			Sig	Sig	Sig		
SE (M) _±	0.86	1.37	1.93			0.10	0.17	0.24			0.38	0.60	0.85		
CD at 5%	2.59	4.10	5.86			0.32	-	0.72			1.14	1.81	2.56		

Table 3: Effect of rootstock and time of grafting on root length, fresh and dry weight shoot

Treatment	Root length (cm) (180DAG)					Fresh weight of shoot (g) (180 DAG)					Dry weight of shoot (g) (180 DAG)				
	Time of grafting					Time of grafting					Time of grafting				
Rootstock	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅
R ₁	16.8	14.1	15.6	14.9	12.8	8.53	8.7	9.24	7.87	7.13	3.16	3.62	3.88	3.13	
R ₂	15.1	18.5	19.1	15.4	14.8	6.92	6.6	8.27	7.15	6.04	2.43	2.8	2.91	2.74	
Mean	15.9	16.3	17.3	15.2	13.8	7.72	7.65	8.75	7.51	6.58	2.79	3.21	3.39	2.93	
	R	T	R X T			R	T	R X T			R	T	R X T		
F - Test	Sig	Sig	Sig			Sig	Sig	Ns			Sig	Sig	Sig		
SE (M) _±	0.33	0.53	0.75			0.16	0.25	0.36			0.06	0.10	0.15		
CD at 5%	1.01	1.60	2.21			0.48	0.76	-			0.20	0.32	0.46		

Table 4: Effect of rootstock and time of grafting on fresh weight, dry weight of Root and shoot to root ratio

Treatment	Fresh weight of root (g) (180 DAG)					Dry weight of root (g) (180 DAG)					Shoot to root ratio				
	Time of grafting					Time of grafting					Time of grafting				
Rootstock	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅	T ₁	T ₂	T ₃	T ₄	T ₅
R ₁	6.7	7.9	7.2	6.4	6.10	2.40	3.0	2.85	2.30	2.15	1.38	1.26	1.18	1.12	1.06
R ₂	8.6	8.15	7.0	7.75	6.63	3.6	3.9	3.0	3.13	2.65	1.14	0.82	1.06	0.88	0.75
Mean	7.65	8.02	7.10	7.07	6.36	2.7	3.4	2.95	2.70	2.40	1.26	1.04	1.12	1.00	0.90
	R	T	R X T			R	T	R X T			R	T	R X T		
F - Test	Sig	Sig	NS			Sig	Sig	Sig			Sig	Sig	NS		
SE (M) _±	0.14	0.23	0.32			0.06	0.10	0.14			0.02	0.03	0.05		
CD at 5%	0.43	0.69	-			0.19	0.30	0.43			0.07	0.11	-		

Conclusion

The present investigation revealed that rootstock and time of softwood grafting significantly influenced graft success and vegetative growth of acid lime cv. PDKV Chakradhar. Among the rootstocks, Rough lemon proved to be the most suitable, recording higher graft success and superior vegetative growth, whereas Rangpur lime exhibited better root development. Among the grafting times, the first week of January was found to be the optimum period, resulting in the earliest sprouting, highest graft success and improved growth attributes. The interaction of Rough lemon grafted during the first week of January (R₁T₃) produced the best overall performance under the agro-climatic conditions of Akola. Therefore, softwood grafting of acid lime cv. PDKV Chakradhar on Rough lemon during the first week of January can be recommended for the production of healthy, vigorous and quality grafted plants.

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