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Vishal A Madavi
PG Scholar, Department of Fruit Science, Post Graduate Institute, Dr. P.D.K.V., Akola, Maharashtra, India

PM Chandan
Assistant Professor, Department of Fruit Science, Post Graduate Institute, Dr. P.D.K.V., Akola, Maharashtra, India

DM Panchbhai
Director of Instruction & Dean Faculty of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

SV Gholap
Assistant Professor, Department of Fruit Science, Post Graduate Institute, Dr. P.D.K.V., Akola, Maharashtra, India

YV Ingle
Assistant Professor, Department of Plant Pathology, AICRP on Fruit (Citrus), Dr. P.D.K.V., Akola, Maharashtra, India

Gourav M. Bhagat
PG Scholar, Department of Fruit Science, Post Graduate Institute, Dr. P.D.K.V., Akola, Maharashtra, India

Corresponding Author:
Vishal A Madavi
PG Scholar, Department of Fruit Science, Post Graduate Institute, Dr. P.D.K.V., Akola, Maharashtra, India

Influence of grafting techniques on compatibility and growth of citrus rootstocks in acid lime CV. PDKV Chakradhar

Vishal A Madavi, PM Chandan, DM Panchbhai, SV Gholap, YV Ingle and Gourav M. Bhagat

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Abstract
An experiment entitled "Influence of Grafting Techniques on Compatibility and Growth of Citrus Rootstocks in Acid Lime cv. PDKV Chakradhar" was conducted during the year 2024-25 at the Fruit Nursery Unit, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with the objective to study the response of different citrus rootstock to grafting techniques in acid lime cv. PDKV Chakradhar. The experiment was laid out in a Factorial Randomized Block Design consisting of different rootstocks as Factor A viz., R_1 (Rangpur lime), R_2 (Rough lemon) and R_3 (Alemow) and grafting methods as Factor B viz., M_1 (Chip budding) and M_2 (Softwood grafting) with six treatment combinations replicated four times. Observations recorded 180 days after grafting included plant height (cm), number of leaves, leaf area (cm²), fresh weight of roots (g), dry weight of roots (g), fresh weight of shoots (g), dry weight of shoots (g) and shoot-to-root ratio. The results revealed that, R_3M_2 (softwood grafting in Alemow) produced significantly higher plant height, number of leaves, fresh and dry shoot weight and shoot-to-root ratio, while R_1M_2 (softwood grafting in Rangpur lime) recorded maximum fresh and dry root weight along with considerable gains in plant height and biomass. The findings indicate that softwood grafting on Alemow and Rangpur lime rootstocks is most effective for producing vigorous and healthy planting material in acid lime cv. PDKV Chakradhar.

Keywords: Acid lime, grafting, rootstock

Introduction
Citrus is one of the most important fruit crops worldwide, cultivated in more than 140 countries, mainly in tropical and subtropical regions between 35°N and 35°S latitudes. Oranges, lemons, limes, grapefruit, and tangerines are the most commercially important species, with China, Brazil and India being the top global producers (Gonzatto & Santos, 2023) [5]. In India, citrus ranks third in area and production after mango and banana, with major cultivation occurring in Andhra Pradesh, Maharashtra, Assam, Meghalaya, Karnataka, Punjab and Rajasthan.

The major commercially cultivated citrus fruits in India include mandarin, sweet orange and acid lime. These fruits are valued for their distinctive aroma, flavour, and nutritional composition serving as rich sources of vitamin C, antioxidants, dietary fibre, and phytochemicals such as carotenoids, flavonoids, and limonoids. Citrus is consumed fresh or processed into juices, squashes, and cordials, and is also utilized in pickles, marmalades, jellies, essential oils, and citric acid production. Such versatility enhances its economic significance in addition to its nutritional value (Rajamanickam *et al*., 2023) [11].

Rootstocks play a vital role in citrus cultivation, influencing tree vigor, yield, fruit quality, and tolerance to various biotic and abiotic stresses. Rough lemon is widely used for its vigor, early bearing, high productivity, and tolerance to tristeza, nematodes, and drought, though it is susceptible to foot rot. Rangpur lime is recognized for producing vigorous, high-yielding trees with good fruit quality, and it shows tolerance to foot rot, tristeza, and calcareous soils. Alemow is a vigorous, fast-growing rootstock tolerant to alkaline and saline soils and adaptable to both tropical and subtropical climates, though its susceptibility to citrus

(Kour *et al*., 2007; Chaudhari *et al*., 1974; Jadhav, 2003) [8, 3, 6]

Material and Methods

The experiment entitled "Influence of Grafting Techniques on Compatibility and Growth of Citrus Rootstocks in Acid Lime cv. PDKV Chakradhar" was conducted in the year during 2024-25 at Fruit Nursery Unit, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with the objective to study the response of different citrus rootstock to grafting techniques in acid lime cv. PDKV Chakradhar. The experiment was laid out in Factorial Randomized Block Design with Factor A as different Rootstock viz., R_1 (Rangpur lime), R_2 (Rough lemon) and R_3 (Alemow) and Factor B as different grafting method viz., M_1 (Chip budding) and M_2 (Softwood grafting) With six treatment combination replicated four times.

Plant Height (cm)

Scion length was recorded after 180 days of success grafting for five plants from each replication of all treatments by measuring scale.

Number of leaves

Number of leaves on scion was recorded after 180 days of grafting and after computing the mean it was recorded as number of leaves.

Fresh weight of roots (g)

Five plants from each replication in each treatment were collected and fresh weight of each root was recorded. The mean fresh weight of roots was calculated from the total number of fresh weights of all roots from each replication and expressed in grams.

Dry weight of roots (g)

Five plants from each replication in each treatment were collected for fresh weight are used for dry weight. These roots of plant are kept under atmospheric temperature for three days then in hot air oven at 60℃ temperature. Mean of all five plants are taken and dry weight of roots was recorded.

Observation recorded: Data was collected after 180 days of grafting to study the response of different citrus rootstock to grafting techniques in acid lime cv. PDKV Chakradhar. The observations are plant height (cm), leaf area (cm^2), fresh weight of roots (g), dry weight of roots (g), fresh weight of shoots (g), dry weight of shoots (g), shoot to root ratio of weight.

Design and statistical analysis: The experiment followed a Factorial Randomized Block Design, with six treatment combinations, each replicated four times. A total of 20 plants were used per replication, following the methodology outlined by Panse and Sukhatme (1967) [10].

Result and Discussion

Plant height (cm)

After 180 days of grafting, the data presented in Table 1 shows significant difference in plant height. Significantly maximum (22.42 cm) height was observed in R_3M_2 (softwood grafting in alemow) which was followed by (20.97 cm) in R_1M_2 (softwood grafting in rangpur lime). The results are in conformity with Yadav *et al*., (2019) [13] in mango.

Number of leaves

The data presented in Table 1 shows significant difference in number of leaves. Singnificantly maximum (37.78) height was observed in R_3M_2 (softwood grafting in alemow) which was at par with (35.38) in R_2M_2 (softwood grafting in rough lemon). The driving forces for cell elongation and multiplication favoured by soil moisture, humidity and temperature which produce favourable effect on number of leaves on scion (Bodkhe and Rajput, 2010) [2].

Leaf area (cm^2)

The data presented in Table 1 shows significant difference in leaf area. Significantly maximum (8.63 cm^2) leaf area was observed in R_2M_2 (softwood grafting in rough lemon) which was at par with (8.33 cm^2) in R_3M_2 (softwood grafting in alemow). The early sprouting is responsible for a greater number of leaves, in turn gave rise to more photosynthesis which might have increased the leaf area at greater extent (Sridhar, 2014) [12].

Fresh weight of shoots (g)

After 180 days of grafting, the data presented in Table 2 shows notable variations in the fresh weight of shoots. Significantly maximum (9.83 g) in R_3M_2 (softwood grafting in alemow) which was at par with (9.50 g) in R_1M_2 (softwood grafting in rangpur lime). Stronger stock-scion interaction, nutrition and moisture absorption and translocation between the stock and scion are necessary for higher biomass accumulation. (Ali *et al*., 1996) [1].

Fresh weight of roots (g)

Table 2 shows the significant difference in fresh weight of roots. Significantly maximum in (8.55 g) in R_1M_2 (softwood grafting in rangpur lime) which was at par with (8.38 g) in R_1M_1 (chip budding in rangpur lime).

Dry weight of shoots (g)

The data presented in Table 2 shows the significant difference in dry weight of shoots. Significantly maximum (3.56 g) weight observed in R_3M_2 (Softwood grafting in alemow) which was at par with (3.37 g) in R_1M_2 (softwood grafting in rangpur lime). Similar results were observed by Khankahdani *et al*., (2019) [7] when Nagpur mandarin budded on Rangpur Lime.

Dry weight of roots (g)

Table 2 shows the significant difference in dry weight of roots. Significantly maximum (3.30 g) weight observed in R_1M_2 (softwood grafting in rangpur lime) which was followed by (3.12 g) in R_3M_2 (softwood grafting in alemow). The results obtained are in agreement with the results of Nikam and Jayant (2021) [9].

Shoot to root ratio (g)

Significantly maximum (1.49 g) in R_3M_2 (softwood grafting in alemow) which was followed by (1.22 g) in R_1M_2 (softwood grafting in rangpur lime). The variation in the shoot to root ratio of the same cultivar grafted on different rootstocks could be attributed to differences in the genetic makeup of the rootstock (Ghule *et al.*, 2019) [4].

Table 1: Effect of rootstock and grafting method on plant height (cm), number of leaves and leaf area (cm^2).

Treatment	Plant height (cm) (180 DAG)			Number of leaves (180 DAG)			Leaf area (cm^2) (180 DAG)		
	Grafting methods			Grafting methods			Grafting methods		
Rootstock	**M_1**	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**
R_1	15.02	20.97	17.99	26.63	32.65	29.64	7.30	8.13	7.71
R_2	15.83	18.38	17.10	18.78	35.38	27.08	7.73	8.63	8.18
R_3	14.94	22.42	18.68	23.45	37.78	30.61	7.40	8.33	7.86
Mean	15.26	20.59		22.95	35.27		7.48	8.36	
	R	**M**	**R x M**	**R**	**M**	**R x M**	**R**	**M**	**R x M**
'F' Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.15	0.12	0.21	0.79	0.65	1.12	0.11	0.09	0.15
CD at 5 %	0.45	0.37	0.64	2.38	1.94	3.37	0.32	0.26	0.45

Table 2: Effect of rootstock and grafting method on fresh weight of shoots (g), fresh weight of roots (g), dry weight of shoots (g) and dry weight of roots (g).

Treatment	Fresh weight of shoots (g) (180 DAG)			Fresh weight of roots (g) (180 DAG)			Dry weight of shoots (g) (180 DAG)			Dry weight of roots (g) (180 DAG)		
	Grafting methods			Grafting methods			Grafting methods			Grafting methods		
Rootstock	**M_1**	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**
R_1	8.15	9.50	8.83	8.38	8.55	8.46	2.72	3.37	3.04	2.89	3.30	3.09
R_2	7.95	8.40	8.18	7.08	7.28	7.18	2.35	3.30	2.83	2.73	2.94	2.83
R_3	8.93	9.83	9.38	7.35	7.53	7.44	2.94	3.56	3.25	2.82	3.12	2.97
Mean	8.34	9.24		7.60	7.78		2.67	3.41		2.81	3.12	
	R	**M**	**R x M**	**R**	**M**	**R x M**	**R**	**M**	**R x M**	**R**	**M**	**R x M**
'F' Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±	0.13	0.11	0.19	0.05	0.04	0.07	0.07	0.06	0.10	0.04	0.03	0.05
CD at 5 %	0.40	0.33	0.57	0.16	0.13	0.22	0.21	0.17	0.29	0.11	0.09	0.16

Conclusion

The production of vigorous and healthy planting material in acid lime depends on multiple factors, among which the choice of rootstock and grafting method plays a decisive role in scion growth and development.

On the basis of the study entitled "Influence of Grafting Techniques on Compatibility and Growth of Citrus Rootstocks in Acid Lime cv. PDKV Chakradhar", the treatment combination R_3M_2 (softwood grafting in alemow) exhibited superior performance in key growth parameters such as plant height, number of leaves, fresh weight of shoots, dry weight of shoots and shoot-to-root ratio. Similarly, R_1M_2 (softwood grafting in rangpur lime) recorded maximum fresh and dry weight of roots, along with notable plant height and biomass accumulation. The overall findings indicate that softwood grafting, particularly on Alemow and Rangpur lime rootstocks, offers significant advantages in enhancing vegetative growth and biomass production of acid lime cv. PDKV Chakradhar seedlings.

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