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Rutuja S Kadu

M.Sc. Fruit Science, College of
Horticulture, Dapoli. Dr.
B.S.K.K.V., Dapoli, Ratnagiri,
M.S., India

Kulkarni MM

Associate Professor (CAS), College
of Horticulture, Dapoli. Dr.
B.S.K.K.V., Dapoli, Ratnagiri
(M.S) India, Maharashtra, India

Dr. PC Haldavnekar

(Ex.), Associate Dean College of
Horticulture, Dapoli. Dr.
B.S.K.K.V., Dapoli, Ratnagiri,
M.S., India

Dr. RV Dhopavakar

Deputy Director of Research
(Agri), Dr. B.S.K.K.V., Dapoli,
Ratnagiri, M.S., India

Dr. Dalvi NV

Associate Professor (CAS), College
of Horticulture, Dapoli. Dr.
B.S.K.K.V., Dapoli, Ratnagiri,
M.S., India

Corresponding Author:

Rutuja S Kadu

M.Sc. Fruit Science, College of
Horticulture, Dapoli. Dr.
B.S.K.K.V., Dapoli, Ratnagiri,
M.S., India

Study on grafting of different pummelo (*Citrus grandis* L. Obseck) varieties on Cv. Konkan Lemon

Rutuja S Kadu, Kulkarni MM, Dr. PC Haldavnekar, Dr. RV Dhopavakar
and Dr. NV Dalvi

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Abstract

Pummelo (*Citrus grandis* L. Osbeck.) is an important and largest citrus fruit crop of tropical and subtropical regions; however, its commercial cultivation in the Konkan region is limited due to the lack of standardized vegetative propagation techniques. In recent years, the demand for red-fleshed pummelo has increased in the Konkan region owing to its attractive fruit quality, high antioxidant content, rich nutritional composition and medicinal properties, including its potential role in promoting health and reducing oxidative stress. The present investigation was undertaken to evaluate the suitability of Cv. Konkan lemon as a rootstock for pummelo grafting and to identify the most appropriate season for softwood grafting of pummelo under Konkan agro-climatic conditions. The experiment was conducted during 2024-2025 at the College of Horticulture, Dapoli, in a factorial randomized block design comprising six grafting seasons and three pummelo varieties. The results revealed significant influence of grafting season and variety on growth and root development. Softwood grafting performed during November with Anjarle Red Fleshed variety recorded the highest graft height, girth, number of leaves, leaf area, root length and root volume, followed by December grafting with the same variety. The superior performance during November (M5) and December (M6) was attributed to maximum temperature (33.17-32.92 °C), minimum temperature (15.09-15.83 °C), high morning relative humidity (88.89-88.91%), moderate evening relative humidity (55.11-57.56%), low wind speed (3.60-3.68 kmph), low rainfall (21.64-33.77 mm), fewer rainy days (0.26-0.66), higher bright sunshine hours (8.71-8.28 hrs) and moderate evaporation (3.65-3.56 mm), which provided favourable conditions for callus formation, graft union establishment, sprouting and survival of pummelo grafts on Konkan lemon under Konkan conditions.

Keywords: Pummelo (*Citrus grandis* L. Osbeck), Konkan Lemon (*Citrus limon*), Softwood Grafting, Compatibility, Sprouting and Growth performance.

1. Introduction

Pummelo (*Citrus grandis* L. Osbeck) is belong to the Rutaceae family, is the largest citrus fruit and a primary ancestor of grapefruit. Native to Southeast Asia and Malaysia, it is cultivated across tropical and subtropical regions for its large, juicy and mildly sweet fruits. Known by various regional names such as Papanas, Batabilebu and Chakkota, pummelo is valued for its high vitamin C content, antioxidants and bioactive compounds. Despite its nutritional and economic importance, the crop remains underutilized due to poor root adaptability, susceptibility to soil-borne diseases and delayed bearing (Kate *et al.*, 2014).

Grafting has emerged as a sustainable technique to overcome these constraints by combining desirable scion and rootstock traits. Cultivar Konkan Lemon, a vigorous and drought-tolerant rootstock well adapted to the Konkan region of Maharashtra, offers strong compatibility with several citrus cultivars, including pummelo. Understanding the graft compatibility and growth response of different pummelo varieties on Konkan Lemon is essential for improving propagation success, orchard performance and long-term sustainability under coastal agro-climatic conditions.

2. Materials and Methods

The present investigation entitled “Study on grafting of different pummelo (*Citrus grandis* L. Osbeck) varieties on Cv. Konkan Lemon” was carried out during the academic year 2024-2025 at the College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth (DBSKKV), Dapoli, District Ratnagiri (M.S.), India. The experiment was conducted at Fruit Crop Nursery No.10. Geographically, Dapoli is situated at 17°45' N latitude and 73°12' E longitude with an altitude of 280 m above MSL. The region represents a humid tropical climate with high relative humidity, warm temperatures and an average annual rainfall of about 2,700 mm. mainly received from June to September.

The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications, comprising two factors - Month (M) and Variety (V) - resulting in 18 treatment combinations. The months of grafting were April (M1), May (M2), June (M3), October (M4), -November (M5) and December (M6), while the pummelo varieties included Anjarle White Fleshed (V1), Anjarle Red Fleshed (V2) and Dapoli-2 (DPLP-2) (V3). Each treatment had 30 grafts per replication, totaling 1620

grafts, raised in 8 cm × 20 cm polybags filled with a mixture of soil, sand and farmyard manure in the ratio of 2:1:1. Healthy 1 year old Konkan Lemon seedlings were used as rootstocks and disease-free scion sticks of uniform thickness and 25 days before grafting defoliated scion sticks were collected from elite mother plants maintained at the 4 No. Nursery, Department of Horticulture, DBSKKV, Dapoli.

The rootstock was decapitated about 8 cm above the collar and a V-shaped slit (3 cm) was made for inserting the wedge-shaped scion. The graft joint was bound with a transparent polyethylene strip (1.5 cm × 45 cm; 200 gauge) to ensure proper cambial contact. The grafts were maintained under shade with regular irrigation and removal of rootstock sprouts. Observations were recorded on sprouting percentage, survival percentage, union height and rootstock girth, number of leaves, leaf area, root length, root volume. Statistical analysis was carried out using FRBD as per the method of Panse and Sukhatme (1985) and treatment means were compared using the F-test and C.D. at 5% probability level.

Table 1: Effect of season and varieties on days required for sprouting, sprouting (%) and Survival (%)

Days required for sprouting of pummelo grafts					Survival (%) of pummelo grafts				Sprouting (%) of pummelo grafts			
Months	Varieties			Mean	Varieties			Mean	Varieties			Mean
	V ₁	V ₂	V ₃		V ₁	V ₂	V ₃		V ₁	V ₂	V ₃	
M ₁	31.16	31.09	34.09	32.11	41.33	48.00	40.00	43.11	33.33	40.00	32.00	35.11
M ₂	32.91	30.08	34.78	32.59	21.33	30.67	18.67	23.56	8.00	17.33	10.67	12.00
M ₃	34.15	33.90	36.08	34.71	57.33	62.67	50.67	56.89	41.33	46.67	29.33	39.11
M ₄	29.13	24.62	30.12	27.96	78.67	78.67	61.33	72.89	70.67	68.00	53.33	64.00
M ₅	23.94	22.13	24.82	23.63	98.67	100.00	97.33	98.67	93.33	94.67	89.33	92.44
M ₆	28.10	22.53	25.08	25.24	96.00	98.67	94.67	96.44	88.00	90.67	89.33	89.33
MEAN	29.90	27.39	30.83	29.37	65.56	69.78	60.44	65.26	55.78	59.56	50.67	55.33
	S.Em. ±	C.D. at 5%		Result	S.Em. ±	C.D. at 5%	Result	S.Em. ±	C.D. at 5%		Result	
M	0.44	1.26		SIG	0.77	2.22	SIG	1.30	3.75		SIG	
V	0.31	0.89		SIG	0.55	1.57	SIG	0.92	2.65		SIG	
M X V	0.76	2.18		SIG	1.34	3.84	SIG	2.26	6.49		SIG	

3. Result and Discussion

Effect of Season and varieties and their interaction days required for sprouting, sprouting (%) and survival (%) on cv. Konkan lemon of pummelo grafts

The interaction effect of season and variety was found to be significant for days required for sprouting, sprouting percentage and survival percentage of pummelo grafts. The earliest sprouting (22.13 days) was recorded in treatment M5V2 (November + ARF), followed by M6V2 (December + ARF) with 22.53 days, whereas the longest period for sprouting (36.08 days) was observed in M3V3 (June + DPLP-2). The maximum sprouting percentage (94.67%) was also recorded in M5V2 (November + ARF), followed by M6V2 (December + ARF) with 90.67%, while the minimum sprouting percentage (8.00%) was observed in M2V1 (May + ARF). The highest survival percentage (100.00%) was recorded in M5V2 (November + ARF), followed by M6V2 (December + ARF) with 98.67%, whereas the lowest survival percentage (18.67%) was recorded in M2V3 (May + DPLP-2). This interaction indicates that genetically responsive varieties express their maximum sprouting potential when grafted under favourable environmental conditions. Optimal temperature and humidity during November enhanced hormonal activity, carbohydrate mobilization and physiological compatibility at the graft union, resulting in rapid bud break and higher sprouting success. These findings are in agreement with earlier reports

emphasizing the synergistic role of season and scion genotype in graft success (Hartmann and Kester, 1979; Nahar *et al.*, 2018; Jayavalli *et al.*, 2024).

The combination recorded the maximum graft height (72.00 cm) at 180 DAG, which was at par with M5V1 (69.03 cm), whereas the minimum graft height was observed in M2V2 (50.10 cm). The superior performance of M5V2 can be attributed to rapid callus formation, early leaf emergence and higher photosynthetic activity, resulting in enhanced vertical growth. These findings are in agreement with earlier reports of Anonymous (2011) and Chalise *et al.* (2016).

The interaction effect noted that the statistically maximum graft height from union (61.75 cm) was observed in treatment M5V2 (November + ARF) which was at par with M5V1 (60.22 cm), Meanwhile, the lowest graft height (42.70 cm) was recorded in M2V3 (May + DPLP-2). The enhanced growth observed under favourable seasonal and varietal combinations can be attributed to rapid callus formation, effective cambial union and improved assimilate accumulation, leading to vigorous scion growth. Similar effects of season and environmental conditions on graft growth have been reported by Chander *et al.* (2016), Kate *et al.* (2014), Karna *et al.* (2017), Bhavya *et al.* (2018) and Kuree *et al.* (2024).

Table 2: Effect of season and varieties on growth parameters of pummelo grafts on Cv. Konkani lemon

Height of pummelo graft from union (cm)				Union girth of pummelo grafts (mm) on Konkani lemon				Rootstock girth of Konkani lemon (mm)			
180 DAG			Mean	180 DAG			Mean	180 DAG			Mean
V ₁	V ₂	V ₃		V ₁	V ₂	V ₃		V ₁	V ₂	V ₃	
46.70	50.02	45.10	47.27	10.73	10.95	9.44	10.37	10.32	11.02	9.73	10.36
43.20	44.25	42.70	43.38	9.87	10.25	9.69	9.94	9.83	9.99	9.69	9.84
48.36	50.23	48.73	49.11	10.16	11.32	10.32	10.60	10.68	11.33	10.55	10.85
53.19	52.88	52.18	52.75	10.78	10.62	11.19	10.86	11.56	11.61	11.25	11.47
60.22	61.75	57.93	59.97	11.93	12.45	10.50	11.63	11.27	12.14	11.81	11.74
54.43	57.78	55.20	55.80	10.91	11.68	10.87	11.15	11.64	12.09	11.40	11.71
51.02	52.82	50.31	51.38	10.73	11.21	10.33	10.76	10.88	11.36	10.74	11.00
S.E.m.+	C.D. at 5%		Result	S.E.m.+	C.D. at 5%		Result	S.E.m.+	C.D. at 5%		Result
0.39	1.12		SIG	0.14	0.41		SIG	0.10	0.28		SIG
0.28	0.79		SIG	0.10	0.29		SIG	0.07	0.20		SIG
0.68	1.94		SIG	0.25	0.71		SIG	0.17	0.49		SIG

At 180 DAG, the statistically maximum rootstock girth of Konkani lemon (12.14 mm) was obtained in treatment M5V2, which was at par with M3V2 (11.33 mm), M5V3 (11.81 mm), M6V2 (12.09 mm). The minimum girth (9.73 mm) was recorded in treatment

was recorded in M1V3. With respect to union girth (12.45 mm) was recorded in treatment M5V2 which was at par with M6V1 (11.93 mm). The minimum girth (9.44 mm) was recorded in treatment M1V3.

Table 3: Effect of season and varieties on growth parameters of pummelo grafts on Cv. Konkani lemon

Treat	No of leaves				Leaf Area				Root length			
	180 DAG			Mean	180 DAG			Mean	180 DAG			Mean
	V ₁	V ₂	V ₃		V ₁	V ₂	V ₃		V ₁	V ₂	V ₃	
M ₁	5.40	5.40	5.03	5.28	462.80	463.00	432.40	452.73	19.40	22.23	17.79	19.81
M ₂	3.72	4.40	3.67	3.93	318.40	377.00	314.20	336.53	17.38	20.61	14.48	17.49
M ₃	6.00	6.30	5.00	5.77	515.80	541.40	429.60	495.60	20.74	20.90	14.93	18.86
M ₄	8.30	8.87	7.77	8.31	712.80	762.00	667.80	714.20	21.02	22.20	19.96	21.06
M ₅	12.67	14.40	11.53	12.87	1085.60	1233.40	987.27	1102.09	22.45	25.47	20.83	22.92
M ₆	10.27	13.53	9.30	11.03	880.00	1159.20	796.60	945.27	22.33	23.22	21.69	22.41
MEAN	7.73	8.82	7.05	7.86	662.57	756.00	604.64	674.40	20.55	22.44	18.28	20.42
	S.E.m.+	C.D. at 5%		Result	S.E.m.+	C.D. at 5%		Result	S.E.m. ±	C.D. at 5%		Result
M	0.30	0.85		SIG	25.74		73.98	SIG	0.47	1.36		SIG
V	0.21	0.60		SIG	18.20		52.31	SIG	0.33	0.96		SIG
M X V	0.51	1.47		SIG	44.59		128.13	SIG	0.82	2.35		SIG

Treatment Details		
Factor - A		Factor - B
M ₁ - April	M ₄ - October	V ₁ - Anjarle White Fleshed (AWF)
M ₂ - May	M ₅ - November	V ₂ - Anjarle Red Fleshed (ARF)
M ₃ - June	M ₆ - December	V ₃ - Dapoli-2 (DPLP-2)

The statistically maximum number of leaves (14.40) was recorded in treatment M5V2 which was at par with (13.53) treatment M6V1, whereas minimum number of leaves (3.67) was recorded in treatment M2V3. The statistically maximum leaf area (1233.40 cm²) was recorded in treatment M5V2, which was at par with treatment M6V2 (1159.20 cm²). The minimum leaf area was observed in treatment M2V3 (314.20 cm²). The maximum root length (25.47 cm) was recorded in treatment M5V2 (November + ARF). This was statistically at par with treatment M6V2 (23.22

cm) (December + ARF). The minimum root length (14.48 cm) was recorded in treatment M2V3 (May + DPLP-2). After 180 days of grafting, the highest root volume (8.77 ml) was recorded in treatment M5V2 (November + ARF), whereas lowest root volume (7.03 ml) was noted in treatment M1V3. The favourable environmental conditions prevailing during these months might have enhanced graft survival, thereby improving economic returns.

Table 4: Average weather parameter after six months of grafting

Period	Tmax	Tmin	RH-I	RH-II	Wind speed	Rain	RD	BSS	Epan
	(°C)	(°C)	(%)	(%)	(Kmph)	(mm)	day	(hrs.)	(mm)
M ₁	30.87	21.81	88.93	77.22	6.06	154.59	3.74	4.21	2.99
M ₂	30.84	21.71	90.25	78.46	5.71	153.50	3.89	3.94	2.95
M ₃	30.53	19.93	92.74	76.00	5.07	151.93	3.70	3.81	2.74
M ₄	32.51	16.56	90.94	60.91	3.63	30.27	1.17	7.27	3.41
M ₅	33.17	15.09	88.89	55.11	3.60	21.64	0.26	8.71	3.65
M ₆	32.92	15.83	88.91	57.56	3.68	33.77	0.66	8.28	3.56

Source: By using Thermo-Hygrometer and collection of data from Department of Agronomy, Dr. B.S.K.K.V. Dapoli

4. Conclusion

Based on the overall performance of growth and survival parameters, Konkan Lemon (*Citrus limon* L.) proved to be a compatible and suitable rootstock for pummelo grafting across seasons and varieties, with no incompatibility observed. Grafting during November and December significantly enhanced graft success with the Anjarle Red Flesh (ARF) variety showing superior response. that enhanced cambial activity and graft union, indicating November and December as the most suitable months for softwood grafting of pummelo on Konkan lemon under Konkan conditions. The superior performance during November (M5) and December (M6) was attributed to maximum temperature (33.17-32.92 °C), minimum temperature (15.09-15.83 °C), high morning relative humidity (88.89-88.91%), moderate evening relative humidity (55.11-57.56%), low wind speed (3.60-3.68 kmph), low rainfall (21.64-33.77 mm), fewer rainy days (0.26-0.66), higher bright sunshine hours (8.71-8.28 hrs) and moderate evaporation (3.65-3.56 mm), which provided favourable conditions for callus formation, graft union establishment, sprouting and survival of pummelo grafts.

The treatment combination M5V2 (November + ARF) consistently resulted in early sprouting, higher survival and sprouting percentages and improved vegetative growth at 180 days after grafting. Thus, grafting pummelo on Konkan Lemon rootstock during November-December is recommended for achieving higher graft success.

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