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Research Article

Performance of different genotypes of pummelo (*Citrus grandis* L.) for softwood grafting success and growth parameters

Shivanand Koti, G. S. K. Swamy, Venkat Rao, J. Jayappa, Jayashree Ugalat

Abstract

Pummelo (*Citrus grandis* L.) is one of the important tropical fruit crops among the citrus group. Since pummelo is a monoembryonic and cross-pollinated crop, vegetative propagation is critical for obtaining true-to-type plants. A study entitled "Performance of different genotypes of pummelo (*Citrus grandis* L.) for softwood grafting success and growth parameters" was carried out in the Department of Fruit Science, College of Horticulture Bengaluru in 2022. The experiment was laid out in a completely randomised design (CRD) with ten genotypes in three replications to know the response of softwood grafting success on locally gathered scions of elite Devanahalli pummelo genotypes was assessed. In February, they were grafted onto six-month-old rangpur lime rootstock. The results revealed that the genotype DSP-8 had recorded the significant minimum days (13) for bud breaking, the maximum graft success (96.67 %) and survivability (100.00 %). The genotype DSP-12 had a significantly maximum graft height at 30, 60, 90 and 120 days after grafting (DAG) (11.60, 14.73, 17.07 and 19.91 cm, respectively) and graft girth at 30, 60, 90 and 120 DAG (3.16, 3.95, 4.95, and 6.01 mm, respectively). Whereas the DSP-5 genotype had recorded significant maximum sprouts at 60, 90 and 120 DAG (3.67, 4.34 and 4.34, respectively) and the DSP-8 genotype had recorded the maximum number of leaves at 30, 60 and 120 DAG i.e., 7.67, 11.67 and 20.34. Among the different genotypes DSP-8 and DSP-12 recorded higher graft success, and these genotypes can be exploited for commercial production.

Keywords pummelo, rootstock, softwood grafting, success, survivability

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Introduction

Pummelo (*Citrus grandis* L.) is one of the significant fruit crops in the citrus group which is belonging to Rutaceae family [1]. Pummelo is a popular fruit in India; it had got a GI tag in the Devanahalli region of Karnataka and is commonly known as chakkota in Kannada. It has a thick, spongy rind and it is the largest citrus fruit, measuring 10 to 25 centimeters in diameter. When ripe, the flesh is tasty and typically has a thin, sweet-tasting peel that ranges from pale green to yellow.

Pummelo can be propagated through the means of seeds or by vegetative methods but propagation by the seeds does not maintain genetic purity and require a longer duration (7-8 years) to bear fruits [2]. However vegetative propagation will ensure that propagated plant material will be identical to the mother plant from which the scion is taken. The planting

material used in most of the commercial pummelo orchards in this region are seedlings in origin, hardly any of them are budded or grafted. Grafting in citrus is becoming increasingly popular and successful nowadays. Softwood grafting is the easiest method to perform with relatively high success compared to other grafting methods [3]. The success and survivability of graft largely depend on scion conditions such as length, vigour, age, node number, variety, rootstock compatibility etc. However, grafted plants produce fruit more quickly (3-4 years). Grafting on the proper rootstock could, to some extent, solve issues with water stress, disease, and poor soil. Pummelos are usually grafted on citrus rootstocks developed from seed. Among them, Rangpur lime (*Citrus limonia* Osbeck), a promising and suggested rootstock, is used in many other states for mandarins and sweet oranges. It is moderately vigorous, productive, salt-tolerant, and resistant to greening, dieback and tristeza [4]. This stock of trees has vigor, prodigious growth, and high-quality fruit production. It pairs well with a variety of citrus fruits, including sweet oranges, Mandarins, and pummelo.

Devanahalli pummelo is one of the best-selling fruits in India, but nowadays farmers are struggling to get true to type planting material and uprooting the plants in old orchards. As there is a lot of variation among the seedlings, the elite types identified by the survey are softwood grafted to know their performance. Hence, this research was carried out to know the graft success percentage of GI-tagged devanahalli pummelo genotypes and supply it to farmers.

Methodology

The current study was carried out at the Horticulture farm, Soppahalli, Chikkaballapur, during the year, 2021-22. The investigational site is located at an elevation of 900 m and lies between 13°30’21” N altitude and 77° 46’43” E longitude. Fully matured, uniformly sized fruits were collected from Rangpur lime trees and seeds were sown in polybags measuring 5 x 8 inches and 300 gauges thick which were filled with soil, sand and FYM in equal proportion. The scions of ten elite pummelo trees in Devanahalli were collected based on morphology, superior fruit yield, and quality and which are free from pests and diseases.

The terminal shoots from the current season growth having 15-20 cm length and nodal buds not less than 8, having pencil thickness were selected and the scions from mother trees were precured ten days before the grafting. The precured scions which were collected early in the morning were grafted on six months old rangpur lime rootstock in February month. Ten treatments in three replications were used in the trial, which was randomized complete block design. Each replication contains ten plants, which were kept in a polyhouse. After 60 days of grafting, the observation of graft success (%) was calculated using the following formula:

(No. of sprouted grafts/Total plant grafted) X 100.

After 120 days, graft survival (%) was calculated using the following formula:

(Survived plant/Graft success plant) X 100.

The number of sprouts per graft, rootstock diameter (mm), Graft height (cm), girth (cm), scion diameter (mm), and number of leaves per plant (nos.) were measured at 30, 60, 90, and 120 days after grafting.

Results and Discussion

Days to bud break

Significant variations were observed in the number of days required for sprouting (Table 1). It took less time for the buds to sprout in DSP-8 (13 days) which is on par with DSP-6 and DSP-12, while genotype DSP-9 (15.67 days) had recorded delayed sprouting. The rapid union between the xylem and cambium tissue of rootstock and scion might favour the survival of sprout [5]. Compared to the findings of Akter et al., [6] and Islam [7] early bud success was observed, which might be due to the procuring of scion [8].

Graft success and survivability

The graft success (Table 1) was recorded as significantly highest (96.67 %) in DSP-8 genotype which was statistically on par with DSP-5 and DSP-6, while the lowest was+ in DAK-1(73.34 %). The plant survivability recorded at 120 days after grafting, results indicated that the genotype DSP-8 recorded significantly higher graft survival (100.00 %), which was statistically on par with DSP-12, DVP-4, while the lowest (77.39 %) was observed in genotype DAK-1. The physiological state of the rootstock, including sap flow, cell dryness, the growth of callus tissues, physiological maturity of the rootstock with higher sugars, and a moderate C: N ratio, determines the percentage of graft success [9-10]. Congenial environment circumstances caused by rapid callusing and early contact with cambial layers, which allowed the graft to heal quickly and form a strong union, could be the cause of the relatively better graft success and plant development inside the polyhouse. [11].

Table 1. Graft success and survivability of different pummelo genotypes

Genotypes	Days to bud break	Per cent success (90 DAG)	Per cent survivability (120 DAG)
DSP-4	14.33	90.00 (71.54) *	88.89 (70.50) *
DSP-5	14.00	93.34 (77.70) *	85.56 (67.97) *
DSP-6	13.67	93.34 (77.70) *	92.97 (77.35) *
DSP-8	13.00	96.67 (83.85) *	100.00 (90.00) *
DSP-9	15.67	90.00 (71.54) *	92.60 (77.00) *
DSP-12	13.50	86.67 (68.83) *	96.30 (83.50) *
DAK-1	14.33	73.34 (58.99) *	77.39 (61.81) *
DBS-1	14.33	80.00 (63.41) *	91.67 (76.18) *
DNR-1	14.67	86.67 (68.83) *	85.19 (71.24) *
DVP-4	15.00	83.34 (66.12) *	91.67 (76.18) *
SE(m)±	**0.33**	**8.28**	**12.00**
CD @ 5%	**0.98**	**2.79**	**4.04**

*Values in parenthesis are arc sin transformed values.
*DAG- Days after grafting

Precuring causes a sudden increase in sucrose content of phloem tissue sap of the precured shoots [8], which helped in the movement of the solutes towards the shoot apex and as a result, there is more meristematic activity at the budding level, as evidenced by their swellings. The above findings are in line with the work of Hussain et al., [12], Deshmukh et al., [10] and Bhandari et al., [13].

Number of sprouts per graft

The number of sprouts was not significantly affected by the softwood grafting at 30 days after grafting however it was significant at 60, 90 and 120 DAG (Table 2). At 60 DAG, the genotype DSP-5 had significantly recorded the highest number of sprouts (3.67) which were on par with the DBS-1 and DVP-4 genotypes. At 90 DAG the maximum numbers of sprouts were found in the genotype DSP-5 (4.34) which was statically on par with the DBS-1 and DSP-8 and there were no new sprouts after 90 DAG, whereas the lowest was recorded in genotype DAK-1 (1.34) at 60, 90 and 120 DAG. Similar readings were reported by Ona et al. [2] in pummelo and Bhandari et al., [13] in mandarin when grafting was done in January.

Number of leaves per graft

The cumulative enhancement of vegetative growth in terms of leaf number was observed significant difference among the genotypes (Table 2 and Figure 1). There were much more leaves per plant, according to the data at 30 and 60 DAG in DSP-8 genotype (7.67 and 11.67 nos. respectively), however, the maximum number of leaves (16.34) was observed in the DBS-1 genotype at 90 DAG, which was on par with DSP-8, DSP-5, DSP-12 and DSP-6. At 120 DAG, a significant maximum number of leaves (20.34) were witnessed in DSP-8 which was on par with DBS-1, whereas the minimum was observed in the

genotype DAK-1 at 30, 60, 90 and 120 DAG (4.34, 5.34, 9.34 and 13.34 respectively).

Table 2. Number of sprouts and leaves on grafts of pummelo genotypes on different days after grafting

Genotypes	Number of sprouts per graft				Number of leaves			
	30 DAG	60 DAG	90 DAG	120 DAG	30 DAG	60 DAG	90 DAG	120 DAG
DSP-4	1.67	2.00	2.34	2.34	5.67	8.34	11.00	15.00
DSP-5	2.00	3.67	4.34	4.34	5.67	10.34	15.00	18.34
DSP-6	1.33	2.00	2.34	2.34	5.00	8.67	14.34	19.00
DSP-8	1.67	2.34	3.34	3.34	7.67	11.67	15.34	20.34
DSP-9	1.67	2.00	2.34	2.34	6.34	8.00	11.34	15.00
DSP-12	1.67	2.67	3.00	3.00	5.34	5.67	14.67	17.67
DAK-1	1.00	1.34	1.34	1.34	4.34	5.34	9.34	13.34
DBS-1	1.67	3.00	3.67	3.67	7.00	9.67	16.34	18.67
DNR-1	1.67	2.67	3.00	3.00	6.67	8.34	13.00	16.34
DVP-4	1.67	3.00	3.34	3.34	5.67	8.67	13.34	17.34
SE(m)±	**0.30**	**0.24**	**0.39**	**0.39**	**0.30**	**0.36**	**0.78**	**0.64**
CD @ 5%	**N/S**	**0.70**	**1.17**	**1.17**	**0.89**	**1.08**	**2.32**	**1.90**

*DAG- Days after grafting

Figure 1. Successful grafts of pummelo genotypes after 60 days of grafting

The difference in leaf number could be a result of early sprouting and the number of sprouts with a plentiful supply of photosynthates, especially carbohydrates (Rob et al., [14]).

Graft height (cm)

Periodic increment in graft height was observed in all genotypes. A significant difference in graft height was observed among the genotypes at 30, 60, 90 and 120 DAG. The average maximum graft height at all intervals was noted in DSP-12 (11.60, 14.73, 17.07 and 19.91 cm at 30, 60, 90 and 120 DAG respectively), which was statistically on par with the DSP-8 at 90 and 120 DAG. While the lowest was observed in DSP-9 at all intervals (6.56, 9.14, 10.95 and 13.93 at 30, 60, 90 and 120 DAG respectively). The rapid and strong combination between the rootstock and scion that results in the rise in graft height may eventually lead to

better nutrition absorption by sprouting shoots [15]. The highest increased length of the graft might be due to the early production of leaves which helped in manufacturing more food and the vigour of the genotype. The slow growth rate might be due to fewer amounts of canopy volume as well as less reserved food causing less physiological activity of the growing rootstock and scion. The current findings are congruent with those of Chalise et al., [16] who reported similar graft height (15.61-19.18) in acid lime.

Graft girth (mm)

The genotypes showed significant variation in the graft girth at various intervals from 30 to 120 days after grafting (Table 3). The genotype DSP-12 recorded significantly higher graft girth at all intervals (3.16, 3.95, 4.95 and 6.01 mm at 30, 60, 90 and 120 DAG respectively) compared to other genotypes. Whereas the lower graft girth was found in DNR-1 at all intervals (2.08, 2.50, 3.11 and 3.57 mm at 30, 60, 90 and 120 DAG respectively). High leaf area and more number of leaves per graft cause the graft to develop quickly, which in turn causes the diameter of the graft to raise the most. This is because the production of photosynthates is mostly dependent on the leaf area and the number of leaves per graft [13]. Similar studies were reported by Widaryanto et al., [17] in pummelo (0.42-.054 cm) and Talukder et al., [18] in mandarin.

Table 3. Graft height and girth of pummelo genotypes on different days after grafting

Genotypes	Graft height (cm)				Graft girth (mm)			
	30 DAG	60 DAG	90 DAG	120 DAG	30 DAG	60 DAG	90 DAG	120 DAG
DSP-4	10.26	13.46	15.21	17.88	2.69	3.19	3.97	4.63
DSP-5	8.42	11.50	13.60	16.65	2.81	3.67	4.29	5.22
DSP-6	10.38	13.74	15.87	18.82	2.73	3.29	4.32	5.46
DSP-8	9.83	13.37	16.70	19.75	2.70	3.54	4.20	5.12
DSP-9	6.56	9.14	10.95	13.93	2.37	2.91	3.42	4.18
DSP-12	11.60	14.73	17.07	19.91	3.16	3.95	4.95	6.01
DAK-1	8.06	10.70	12.20	15.02	2.85	3.67	4.46	5.22
DBS-1	8.94	11.62	13.23	15.80	2.26	2.91	3.48	4.19
DNR-1	8.79	11.87	13.50	16.55	2.08	2.50	3.11	3.57
DVP-4	7.93	11.11	12.77	15.71	2.88	3.55	4.54	5.47
SE(m)±	**0.19**	**0.17**	**0.19**	**0.17**	**0.05**	**0.05**	**0.04**	**0.04**
CD @ 5%	**0.56**	**0.50**	**0.56**	**0.48**	**0.15**	**0.15**	**0.13**	**0.12**

*DAG- Days after grafting

Conclusion

The findings of softwood grafting on six month old Rangpur lime rootstock indicated that the genotypes DSP-8 and DSP-12 among the different genotypes recorded higher graft success, survivability and vegetative parameters and can be exploited for commercial production.

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