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Effect of season and polytube cover cap on softwood grafting in lemon (*Citrus limon* L.) cv. Konkan lemon

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Abstract
An experiment was conducted to study the effect of season and polytube cover cap on growth and survival percentage in softwood grafting of lemon (*Citrus limon* L.) cv. Konkan Lemon at department of Horticulture, College of Agriculture, DBSKKV, Dapoli during year 2015-17. The result shows that minimum days required for sprouting (15.50), the highest sprouting percentage (86.15), survival percentage (73.23), and girth of new sprout (2.84 mm) were recorded in T4 (Polytube cover cap on graft in June) While highest number of leaves (29.40), and leaf area (25.99 cm2) were found in T6 (Polytube cover cap on graft in August) while length of new sprout (15.97 cm) were found highest in T2 (Polytube cover cap on graft in April). Observations were noticed at the end of 90 days after sprouting. Season and polytube cover cap on graft during the period of June to August was proved to be the best.

Keywords: Soft wood grafting, season, lemon, polytube cover cap

Introduction
Lemon (*Citrus limon* L.) is an important citrus fruit worldwide. It belonging to the family Rutaceae with chromosome number (2n=18). It is known as limboo in marathi and nimbu in hindi. The health and other benefits of lemon are having antioxidant properties, lemon juice is often added to fresh fruit to prevent oxidation and browning, peel is used as flavouring or candied, oil obtained from the peel is used as a wood cleaner and polish and as a non-toxic pesticide. It commercial source of citric acid. The exact origin of lemon has remained in a mystery, though it is widely presumed that lemon first grew in North Eastern India and Burma (Hodgson, 1967) [11]. In India, Andhra Pradesh is the leading state with highest area (34.50 thousand hectare) and production (496.84 thousand tonnes). While Andaman & Nicobar Islands having highest productivity with 8.33 tonnes per hectare (Annon. 2015). Maharashtra is the fourth largest producer state in the country. It produces 11% of total production of lemon in the country i.e. 194.66 thousand tonnes of lemon from an area of 19.90 thousand hectares with productivity of 9.78 tonnes/ha. Lemon is mainly propagated by seed, stem cutting and air layering. In case of seed propagation, there are some disadvantages. In some cases, seedlings are not true-to-type with mother tree due to juvenility factors, seedling trees do not usually bear fruit until they are nearly a decade old and they are vulnerable to unfavourable soil conditions, diseases, and so forth. But the vegetative method of propagation is desirable because it enables to retain the characteristics of the mother plant, to get flower and fruit earlier, to remain initially relatively smaller with the benefit of more plants accommodation per unit area and to give the growers earlier fruit and more economic benefit. In case of stem cutting there are some disadvantages such as adventitious roots are produced, which are weaker than the tap root system. Thus the resultant plant becomes poor, short life span and less yielder. This concluded that propagation through vegetative means is desirable to multiply genotypes. Although vegetative propagation methods like air layering is practiced, it is relatively cumbersome method as it requires involving more labour and material cost (Chadha, 2014) [5]. Survival percentage and growth of grafts depend on a number of factors including time and method of grafting, defoliation period of scion, age of the rootstock, leaf retention of rootstock etc. Among these defoliation period of scion and leaf retention on rootstock are important factors for success, survivability and growth of grafts (Aftab, 2004). Through defoliation and cutting the tip of the twigs dormant lateral axillary buds present on selected branches were made into active condition and defoliation enhanced the success of grafting. Alternatively softwood grafting have been recently tried with varying success in lemon and other fruit crops (Banik, 2014) [4]. In view of this an attempt was made to study the effect of season and polytube cover cap on softwood grafting in lemon under Konkan climatic conditions.

Materials and Methods

The experiment was conducted at the Department of Horticulture, College of Agriculture Dapoli, Dist. Ratnagiri (M.H) during the period 2015-17. The experiment was conducted in Randomized Block Design (RBD) with 12 treatments and three replications. The treatments were T_1: No polytube cover cap on graft in April, T_2: Polytube cover cap on graft in April, T_3: No polytube cover cap on graft in June, T_4: Polytube cover cap on graft in June, T_5: No polytube cover cap on graft in August, T_6: Polytube cover cap on graft in August, T_7: No polytube cover cap on graft in October, T_8: Polytube cover cap on graft in October, T_9: No polytube cover cap on graft in December, T_{10}: Polytube cover cap on graft in December, T_{11}: No polytube cover cap on graft in February, T_{12}: Polytube cover cap on graft in February Fresh mixed seeds of lemon (*Citrus limon* L.) were used for raising of rootstock. The seeds were sown individually in polythene bags of 15 cm x 20 cm size containing potting mixture of soil and F.Y.M in the ratio of 3:1. Regular and uniform hand watering was given as per requirement. The softwood grafting operation was performed by the method described by Amin (1974) [2]. The top portion of the fresh growth developed on the stock plant was decapitated with knife keeping about 8.0 cm fresh stem. Then a top portion of seedlings was carefully split vertically in 'V' shape up to 3 cm length. The cut portion looked like a fork or letter 'V'. The scion of about the same thickness as that of stock was selected having a length of 10 cm. Thereafter, the lower end of the scion was mended to 3 cm wedge by chopping off bark and little wood from two equal opposite sides. The wedge of scion was inserted into 'V' shaped slit of stock and secured firmly with 1.5 cm wide and 45 cm long and 200 guage thick white transparent polythene strip. The prepared grafts were covered from top by polytube cap 25 cm x 7.5 cm size as per the treatment. The bag was retained on the graft for one month or till sprouting was observed of the graft. Five lemon grafts in each treatment per replication were selected randomly to record observations.

Results and discussion

Days required for sprouting

The data pertaining to the effect of season and polytube cover cap over grafts on days required for sprouting of softwood grafting in lemon. The earliest sprouting was observed in T_4 (15.50 days) which was at par with T_6 (15.67 days) followed by T_2 (17.17 days), T_3 (17.17 days), T_5 (18.00 days), T_1 (18.33 days), T_{10} (18.50 days) and T_8 (18.83 days). The delayed sprouting was found in T_{11} (23.33 days) followed by T_{12} (20.33 days), T_7 (20.33 days) and T_9 (19.83 days).

$$T_{11} > T_{12} = T_7 > T_9 > T_8 > T_{10} > T_1 > T_5 > T_3 = T_2 > T_6 > T_4$$

The season and polytube cover cap over graft had significant influence on days required for sprouting. The use of younger scion and polytube cover cap on graft resulted in early sprouting. In the young tissue of softwood scion higher meristematic activities take place which are responsible for higher rate of multiplication of tissues (Hartmann *et al*., 2002) [10]. The polythene bag cover reduced rate of transpiration and increased humidity around graft joint, which protected the tissues in graft joint from desiccation (Haldankar *et al*., 1997) [9]. The congenial weather conditions prevailing during grafting period triggered cell activity in scion which results in early sprouting of scion (Shinde *et al*., 2011) [17]. Similar results were reported by Dewangan *et al*. (2016) [7] reported that poly tube covering was significantly superior in days required for sprouting of Mango grafts. Sonawane *et al*. (2012) [18] noticed minimum days required for sprouting in Carambola softwood grafts when scions covered with polythene bags during August.

Sprouting and survival percentage (%)

The results recorded due to effect of season and polytube cover cap over grafts on sprouting and survival percentage of softwood grafting in lemon. The maximum sprouting percentage was observed in treatment T_4 (86.15) which showed the superiority over all other treatments i.e. polytube cover cap on graft in June. It was followed by T_{10} (76.83) which was at par with T_6 (76.73) then followed by T_2 (68.63), T_{12} (67.63), T_5 (67.27), T_9 (66.51), T_1 (66.43) and T_3 (65.41). The minimum sprouting percentage was recorded in T_7 (49.22) which was at par with T_8 (50.60), followed by T_{11} (60.01).

$$T_4 > T_{10} > T_6 > T_2 > T_{12} > T_5 > T_9 > T_1 > T_3 > T_{11} > T_8 > T_7$$

The highest survival percentage was observed in T_4 (73.23) which was at par with T_6 (72.25). It was followed by T_2 (65.69), T_{10} (63.45), T_5 (60.72), T_3 (60.27) and T_9 (59.82). The minimum survival percentage was observed in T_{11} (40.78) which was at par with T_7 (43.85) followed by T_{12} (46.15), T_8 (47.68) and T_1 (55.17).

$$T_4 > T_6 > T_2 > T_{10} > T_5 > T_3 > T_9 > T_1 > T_8 > T_{12} > T_7 > T_{11}$$

Thus, it was observed that season and polytube cover cap over graft had significant influence on sprouting and survival percent of grafts. The covering of polytube cap over scion protects the vital buds from direct sunlight, desiccation and also modifies temperature around the buds and thus reduces the mortality percentage (Joshi *et al.,* 2016) [14]. The higher success of grafting during June and August months may be attributed to the congenial weather conditions (higher maximum and minimum temperature and optimum humidity) prevailed during these months, resulting in increased cell activity leading to better union of stock and scion (Pampanna and Sulikeri, 2000) [16]. These results are in close conformity with the results Joshi *et al*. (2014) [13] recorded maximum sprouting when grafts covered with polycap during July in wedge grafting of Guava. Sonawane *et al.* (2012) [18] recorded higher survival percentage of Carambola softwood grafts when scions were covered with polythene bags during June to August.

Number of leaves

The data on number of leaves recorded due to effect of season and polytube cover cap over grafts on the softwood grafting in lemon. At 45 DAS, maximum number of leaves were found in T_6 (24.80) which was at par with T_4 (23.10) and T_2 (19.40) followed by T_{10} (17.50), T_3 (16.50), T_8 (16.00) and T_5 (15.00). The lowest number of leaves on grafts was observed in T_{11} (7.00) which was at par with T_7 (10.20) and T_9 (10.30) followed by T_{12} (13.20) and T_1 (13.90).

At 45 DAS

$$T_6 > T_4 > T_2 > T_{10} > T_3 > T_8 > T_5 > T_1 > T_{12} > T_9 > T_7 > T_{11}$$

At 90 DAS

$$T_6 > T_4 > T_2 > T_{10} > T_3 > T_8 > T_5 > T_1 > T_{12} > T_9 > T_7 > T_{11}$$

At 90 DAS, the maximum number of leaves were recorded in T_6 (29.40) which was at par with T_4 (29.30), T_2 (26.70), T_{10} (24.00), T_3 (23.30) and T_8 (22.70). The minimum number of leaves on graft were recorded in T_{11} (14.10) which was at par with T_7 (15.90), T_9 (18.10), T_{12} (18.30), T_1 (19.40) and T_5 (20.40). Thus, it was observed that season and polytube cover cap over graft had significant influence on number of leaves. The polytube cover cap on graft creates a microclimate for growth of the grafts which helps in fast cambium activity which results in early sprouting and optimum maturity of scion with congenial environmental conditions promote the growth of the grafts results in maximum number of leaves. These results are in close conformity with the results of Ghosh *et al*. (2010) obtained maximum number of leaves in the month of June with polythene cap covered over grafts in softwood grafting of Sapota.

Leaf Area (cm^2)

The data on effect of season and polytube cover cap over grafts on leaf area of softwood grafting in lemon. At 45 DAS, the highest leaf area was recorded in T_4 (19.19 cm^2) which was at par with T_6 (19.01 cm^2) and T_2 (18.39 cm^2) followed by T_{10} (13.67 cm^2), T_3 (12.69 cm^2) and T_5 (11.51 cm^2). The minimum leaf area was recorded in T_{11} (7.68 cm^2) which was at par with T_7 (8.25 cm^2), T_9 (9.50 cm^2), T_1 (10.03 cm^2), T_{12} (10.04 cm^2) and T_8 (10.79 cm^2). At 90 DAS, highest leaf area was recorded in T_6 (25.99 cm^2) which was at par with T_4 (25.39 cm^2) and T_2 (23.99 cm^2) which was followed by T_{10} (19.33 cm^2), T_3 (16.01 cm^2), T_8 (15.85 cm^2). The minimum leaf area was recorded in T_{11} (12.39 cm^2) which was at par with T_9 (12.66 cm^2), T_7 (12.67 cm^2), T_1 (13.14 cm^2), T_{12} (13.42 cm^2) and T_5 (14.61 cm^2). The pattern of variation in different treatments in descending order is detailed below:

At 45 DAS

$$T_4 > T_6 > T_2 > T_{10} > T_3 > T_5 > T_8 > T_{12} > T_1 > T_9 > T_7 > T_{11}$$

At 90 DAS

$$T_6 > T_4 > T_2 > T_{10} > T_3 > T_8 > T_5 > T_{12} > T_1 > T_7 > T_9 > T_{11}$$

Thus, it was observed from the above data that season and polytube cover cap over graft had significantly influenced the leaf area. The polythene tube cover might have reduced rate of transpiration and increased humidity around graft joint, which must have protected the tissues in graft joint from desiccation. The congenial weather conditions available during grafting and growth period resulted into early sprouting of grafts, probably due to early sprouting grafts took maximum duration for growth as compared to other treatments. As the number of leaves increased the metabolic activity of cell is doubled which results in healthy and vigorous growth of grafts (Khatun *et al*., 2008) [15]. Similar results were obtained by Chander *et al*. (2016) [6] who recorded maximum leaf area in softwood grafting of Jamun when scions were covered with polythene cap in the month of September.

Length (cm) and girth (mm) of new sprout

The data on length and girth of new sprout of softwood grafting in lemon with respect to effect of season and polytube cover cap over grafts.

Length of new sprout

At 45 DAS, the maximum length of new sprout was observed in T_2 (9.98 cm) which was at par T_4 (9.59 cm), T_6 (9.00 cm) and T_{10} (8.11 cm) followed by T_8 (6.74 cm) and T_{12} (6.69 cm). The minimum length of new sprout was recorded in T_{11} (2.81 cm) which was at par with T_7 (3.79 cm), T_9 (3.96 cm) and T_1 (4.77 cm) followed by T_5 (5.71 cm) and T_3 (6.22 cm).

At 45 DAS

$$T_2 > T_4 > T_6 > T_{10} > T_8 > T_{12} > T_3 > T_5 > T_1 > T_9 > T_7 > T_{11}$$

At 90 DAS

$$T_2 > T_4 > T_6 > T_{10} > T_8 > T_{12} > T_3 > T_5 > T_1 > T_9 > T_7 > T_{11}$$

At 90 DAS, the maximum length of new sprout was recorded in T_2 (15.97 cm) which was at par T_4 (15.95 cm) and T_6 (12.47 cm) followed by T_{10} (10.90 cm), T_8 (10.73 cm), T_{12} (8.71 cm) and T_3 (8.59 cm). The minimum length of new sprout was assessed in T_{11} (3.83 cm) which showed significantly least difference, which was at par with T_7 (5.69 cm), T_9 (6.09 cm), T_1 (6.32 cm) and T_5 (7.89 cm). The pattern of variation in different treatments in descending order is detailed below:

Girth of new sprout

At 45 DAS, the maximum girth of new sprout was recorded in T_4 (1.89 mm) which was at par with T_6 (1.73 mm), T_2 (1.71 mm), T_{10} (1.70 mm), T_8 (1.69 mm), T_3 (1.66 mm) and T_5 (1.65 mm). The minimum girth of new sprout was observed in T_7 (1.12 mm) which was at par with T_{11} (1.32 mm) followed by T_9 (1.40 mm), T_1 (1.50 mm) and T_{12} (1.51 mm).

At 45 DAS

$$T_4 > T_6 > T_2 > T_{10} > T_8 > T_3 > T_5 > T_{12} > T_1 > T_9 > T_{11} > T_7$$

At 90 DAS

$$T_4 > T_6 > T_2 > T_{10} > T_8 > T_3 > T_5 > T_{12} > T_1 > T_9 > T_{11} > T_7$$

At 90 DAS, the maximum girth of new sprout was observed in T_4 (2.84 mm) which was found to be at par with T_6 (2.82 mm), T_2 (2.58 mm), T_{10} (2.45 mm), T_8 (2.38 mm), T_3 (2.30 mm) and T_5 (2.24 mm). The minimum girth of new sprout was recorded in T_7 (1.66 mm) which was at par with T_{11} (2.02 mm), T_9 (2.04 mm), T_1 (2.18 mm) and T_{12} (2.22 mm). Thus, it was observed that season and cover over graft had significant effect on length and girth of new sprout. The cover over grafts helps better growth of grafts, grafted during June and August months which can be correlated to the higher cell activity and early sprouting which was responsible for more number of leaves, in turn give rise to more photosynthesis which might have increased growth of scion shoot to greater extent and gives more number of branches. (Sridhar, 2014) [19]. These results are in close conformity with the results of Islam (2012) [12] obtained maximum length of new shoot in the month of June in cleft grafting of Mango when scions covered with polythene cap. Joshi *et al*. (2016) [14] recorded maximum girth of sprout when scions were covered with polycap in wedge grafting of Guava.

Table 1: Effect of season and polytube cover cap over grafts on days required for sprouting, Sprouting & Survival (%) and No. of leaves of softwood grafting in Lemon.

Treatments	Days required for sprouting	Sprouting percentage	Survival Percentage	No. of leaves	
				45 DAS	90 DAS
T_1	18.33	84.00 (66.43)	67.33 (55.17)	13.90	19.40
T_2	17.17	86.67 (68.63)	83.00 (65.69)	19.40	26.70
T_3	17.17	82.67 (65.41)	75.33 (60.27)	16.50	23.30
T_4	15.50	98.67 (86.15)	91.67 (73.23)	23.10	29.30
T_5	18.00	85.00 (67.27)	76.00 (60.72)	15.00	20.40
T_6	15.67	94.67 (76.73)	90.67(72.25)	24.80	29.40
T_7	20.33	57.33 (49.22)	48.00 (43.85)	10.20	15.90
T_8	18.83	59.67 (50.60)	54.67 (47.68)	16.00	22.70
T_9	19.83	84.00 (66.51)	74.67 (59.82)	10.30	18.10
T_{10}	18.50	94.67 (76.83)	80.00 (63.45)	17.50	24.00
T_{11}	23.33	74.67 (60.01)	42.67 (40.78)	7.00	14.10
T_{12}	20.33	85.33 (67.63)	52.00 (46.15)	13.20	18.30
Range	15.50 - 23.33	57.33-98.67 (49.22-86.15)	42.67-91.67 (40.78-73.23)	7.00-24.80	14.10-29.40
Mean	18.58	82.28	69.67	15.58	21.80
S.E.±	0.43	1.74	1.05	1.86	2.73
C.D. at 5 %	1.25	5.12	3.08	5.46	8.02
Result	SIG	SIG	SIG	SIG	SIG

Table 2: Effect of season and polytube cover cap over grafts on leaf area and length & girth of new sprout of softwood grafting in Lemon.

Treatments	Leaf Area (cm^2)		Length of new sprout (cm)		Girth of new sprout (mm)	
	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS
T_1	10.03	13.14	4.77	6.32	1.50	2.18
T_2	18.39	23.99	9.98	15.97	1.71	2.58
T_3	12.69	16.01	6.22	8.59	1.66	2.30
T_4	19.19	25.39	9.59	15.95	1.89	2.84
T_5	11.51	14.61	5.71	7.89	1.65	2.24
T_6	19.01	25.99	9.00	12.47	1.73	2.82
T_7	8.25	12.67	3.79	5.69	1.12	1.66
T_8	10.79	15.85	6.74	10.73	1.69	2.38
T_9	9.50	12.66	3.96	6.09	1.40	2.04
T_{10}	13.67	19.33	8.11	10.90	1.70	2.45
T_{11}	7.68	12.39	2.81	3.83	1.32	2.02
T_{12}	10.04	13.42	6.69	8.71	1.51	2.22
Range	7.68-19.19	12.39-25.99	2.81-9.98	3.83-15.97	1.12-1.89	1.66-2.84
Mean	12.69	17.12	6.45	9.43	1.57	2.31
S.E.±	1.25	1.31	0.93	1.49	0.09	0.20
C.D. at 5 %	3.68	3.84	2.72	4.38	0.27	0.60
Result	SIG	SIG	SIG	SIG	SIG	SIG

Conclusion

It can be concluded that, season and polytube cover cap over graft had significant effect on softwood grafting in lemon. Season and polytube cover cap on graft during the period of June to August was proved to be the best for the days required for sprouting, sprouting and survival percentage, number of leaves, leaf area, length of new sprout and girth of new sprout. Hence, it was found to be the best for maximum survival of grafts under agro climatic conditions of Konkan region of Maharashtra.

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