International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 9 (1) : 97- 104, June 2023

Effect of types of rootstocks and their age on performance of cleft grafting of sweet orange (*Citrus sinensis*) cv. BARI Malta-1

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Received : 27.02.2023 ; Revised : 19.05.2023 ; Accepted : 20.05.2023

DOI : 10.53552/ijmfmap.9.1.2023.97-104

ABSTRACT

A suitable rootstock as well as rootstock age is predominating factor for production of quality planting materials (saplings). This study was conducted to find out a suitable rootstock as well as age of rootstock for successful grafting of BARI Malta-1. The experiment was conducted at pomology division of Horticulture Research Center, BARI. The factorial experiment consists of two types of rootstocks viz., R_1: Rangpur lime and R_2: Rough lemon and nine different ages of the rootstocks viz., 5^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th}, 11^{th},12^{th} and 13^{th} months. Thus eighteen treatment combinations were used for this study. Healthy, diseases free and ideal scion of sweet orange was grafted on to rootstocks following cleft method. The results showed that the treatment combination R_2T_3 (Sweet orange scion grafted on 7^{th} months old rough lemon rootstock) was performed better among the all combinations as it gave the highest results in respect of plant height (64.42 cm), canopy volume (0.042 cm^3), number of leaves per plant (61.00), stem fresh weight (32.38 g) and total chlorophyll (1.44 mg/g tissue). The treatment combination R_2T_3 also showed 80% graft survivability after one year of grafting. These results suggest that sweet orange cv. BARI Malta-1 should be grafted on 7^{th} months old rough lemon rootstock in cleft grafting method for achieving better planting materials.

***Keywords*:** *Cleft grafting, graft morphology, graft physiology, rootstock age, rootstock type, sweet orange*

INTRODUCTION

In Bangladesh sweet orange (*Citrus sinensis*) is commonly known as Malta. Sweet orange is getting popular day by day in Bangladesh and farmers are very interested to cultivate it. Bangladesh Agricultural Research Institute developed two sweet orange varieties and they are BARI Malta-1 and BARI Malta-2. BARI Malta-1 is high yielding and getting popular among the farmers since it can grow almost all over the country. It is medium size and about 146 g of weight, number of fruit per plant is 300-400, yield is 20 tons/hectare, very juicy (33.7%) and sweet (TSS 7.8% and total acid 0.36%). External appearance of fruit is smooth, round in shape and skin is very thin. One of the most important factors contributing towards high productivity of sweet orange is quality planting material. In Bangladesh, mainly seed propagation is practiced which takes long duration to get maturity and fruiting as well as attributed to low fruit qualities due to high genetic variations. For heterozygosity of fruit crops, usage of vegetative multiplied planting material is the scientific way (Ghosh and Bera, 2015). Propagation by cleft grafting is the easiest method in sweet orange in Bangladesh. In fruit crops rootstocks have been utilizing for long period to defend against soil born diseases and pests (Ranpise and Ahire, 2016). As an ancient practice, grafting delivers several agronomical benefits to citrus crops. Using of a proper rootstock can have significant developments for the scion such as decline of the juvenility period, excessive yield, better fruit quality, uniform plant architecture, guard against pests and diseases, and appropriate tolerance to abiotic stress factors (Balfagón *et al.*, 2022). Various factors influence the success and survivability of grafts viz. time of grafting operation, varieties, maturity and age of scion and rootstock, growing condition of grafts, methods of grafting etc. For a graft union to be effective, it is required that temperature states in

the times of cellular activity, callus construction in addition to during healing should be supportive. The grafting operation normally carried out while the temperatures are appropriate for cambial action and there is the high humidity in the surrounding area of the cambial zone of the graft joint. Effective balance recognized between grafted scions with leaves and rootstocks' roots are very much required for boosting assimilates partitioning plus free transmission of water plus necessary nutrient element (Perez-alfocea *et al*., 2010). Nevertheless, leaf chlorophyll also found to have considerable impact on the propagation accomplishment as well as plant persistence. Better root and scion composition improved the biomass of root, length of root, root: shoot ratio as well as whole biomass accumulation in Khasi mandarin (Deshmukh *et al*., 2017). Thus, the variations in the level of morpho-physiological features of scion leaves of grafts as sources are determined by the rootstocks age and type of rootstocks. Therefore, detection of suitable age of different rootstocks along with appropriate morphological and anatomical features is essential to know its effect on development of scion (Zoric *et al.*, 2012), multiplication success and plant persistence. Grafting of different aged rootstocks can satisfy the need of grafts to be united at whichever period of the year and thus we can do year round grafting to fulfill the high demand of sweet orange saplings. Leaf and shoot attributes, root growth and morphology study is applicable for development and tuning of multiplication procedures. Information related to the effect of age of rootstock at scion physiology and root morphology of grafted plants are not sufficient for sweet orange. There is immense scope of employment and income generation through year round production and supply of quality planting materials of sweet orange as well as other citrus fruits. Keeping in view all these points, the present study was under taken to investigate the grafting performance of different aged citrus rootstocks on sweet orange.

MATERIALS AND METHODS

The investigation was conducted at the Fruit Research Farm of the Pomology Division of Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during the period from October, 2016 to November, 2018; which is located at 23°59'02'' N latitude and 90°24'38'' E longitude with an altitude of 15 m above sea level with silt loam to silty clay loam in soil texture with the pH varying from 4.5 to 7.2 (FRG, 2012), average temperature and humidity was 26° and 85% respectively during the experiment. The experiment consisted of two factors with eighteen treatment combinations which were as follows; Factor A: Types of rootstocks; R_1: Rangpur lime (*Citrus limonia* Osbeck) rootstock and R_2: Rough lemon (*Citrus jambhiri* Lush) rootstock. Factor B: Different ages of rootstocks (T_1: Five months old rootstock, T_2: Six months old rootstock, T_3: Seven months old rootstock, T_4: Eight months old rootstock, T_5: Nine months old rootstock, T_6: Ten months old rootstock, T_7: Eleven months old rootstock, T_8: Twelve months old rootstock, T_9: Thirteen months old rootstock). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were eighteen treatment combinations in each replication. For each treatment combination grafting operations had performed on 10 rootstocks, so for one replication 180 and total 540 number of grafting work was performed. The treatment combination was randomly assigned. Seeds of each rootstock collected from ripen fruits and immediately sown on 10th October 2016 in germination tray separately and after germination when seedlings achieved two to three leaves stage they were transferred to polybag (15 cm x 10 cm) respectively. After five months of when these rootstocks were grown up, then among them healthy, vigorous, pest and disease free, uniform in size and growth were selected for first cleft grafting work for the experiment and it continued every month till the thirteen-month age of the rootstock according to the treatment combinations. After wrapping the graft union, the scion along with the union portion was covered with a polythene cap and kept in the grafting chamber where temperature can be controlled to protect the scion from the loss of moisture through transpiration. Proper care and management of the grafts were taken to maintain their good health. All the data on different parameters were recorded at one year age of grafted sapling except days to bud breaking and graft success.

The methodology used to take data in respect of days to bud breaking, percentage of graft success was calculated by using the following formula: Percentage of graft success = Number of successful grafts × 100/Total number of grafted rootstock), graft survivability percentage was measured by using the following formula:

Graft survivability (%) = Total number of successful grafts - Total number death of grafts after success) × 100/ Total number of successful grafts} (Chakma *et al.*, 2013), number of leaves per plant, leaf area (m^3), leaf fresh weight (g), leaf turgid weight (g), leaf dry weight (g),

Relative water content = {RWC of fresh leaves was calculated using the following formula: RWC (%) = (leaf fresh weight - leaf dry weight) × 100/ (leaf turgid weight - leaf dry weight)} (Deshmukh *et al.*, 2017).

Chlorophyll a, chlorophyll b and total chlorophyll content of leaves was determined according to the method described by Witham *et al.* (1971), the amount of chlorophyll was determined by using these following formul as (Arnon, 1949);

$C_a = 0.0127\ D_{663} - 0.00269\ D_{645}$, $C_b = 0.0229\ D_{645} - 0.00468\ D_{663}$ and $C = C_a + C_b$, Where D=Density values at the respective wavelengths as obtained on the spectrophotometer, C_a=Chlorophyll a, C_b=Chlorophyll b, C=Total chlorophyll. Chlorophyll content was expressed in mg/g tissue.

Plant height (m), rootstock diameter (mm), scion diameter (mm), stem fresh weight (g), stem dry weight (g), root volume (cm^3), root fresh weight (g), root dry weight (g), root: shoot ratio (The root to shoot ratio was computed by using following formula; Root: Shoot = Root dry weight/Shoot dry weight where, After weighing fresh weight, each sample was kept in paper envelop separately according to the treatment combination and placed in an electrical oven for 72 hours in 65°C. Weight of fresh and oven dried samples was recorded by an electrical balance in g. Collected data were analyzed by following statistical package software R.

RESULTS AND DISCUSSION

The data presented in Table 1 indicated that combination of rootstocks and rootstock age had significant effect on days to bud break of sweet orange grafts. The longest (25 days) days were required to bud break for R_2T_4 (Sweet orange scion grafted on eight months old rough lemon rootstock) and followed (24 days) by R_1T_5 (Sweet orange scion grafted on nine months old Rangpur lime rootstock). The shortest (12 days) days were required for R_1T_2 (Sweet orange scion grafted on six months old Rangpur lime rootstock), R_2T_1 (Sweet orange scion grafted on five months old rough lemon rootstock) and R_2T_2 (Sweet orange scion grafted on six months old rough lemon rootstock) to bud break (Table 1).

Combined effect on sweet orange graft success was maximum (100.00%) when it was R_1T_2(Sweet orange scion grafted on six months old Rangpur lime rootstock) and it was statistically significant from other combined effect. R_1T_3 (Sweet orange scion grafted on seven months old Rangpur lime rootstock) R_1T_8 (Sweet orange scion grafted on twelve months old Rangpur lime rootstock), R_2T_2 (Sweet orange scion grafted on six months old rough lemon rootstock), R_2T_6(Sweet orange scion grafted on ten months old rough lemon rootstock), R^2T^7(Sweet orange scion grafted on eleven months old rough lemon rootstock) showed the second highest (96.67%) integration effect on graft success. The proper rootstock age with greater sugars and adequate C: N ratio should have added to the greater graft success percentage. The prompt failure in success of graft in different treatments can be as a result of lack of vigorous sprouts, physiological state of the rootstock as well as weakened sap flow which eventually affected the growth of graft union establishment. Minimum (63.33%) combined effect showed by R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) on graft success (Table 1).

Rootstocks and rootstock ages also had no significant combined effect on graft survivability of sweet orange grafts. Maximum (93.33%) graft survivability of sweet orange graft found when it was grafted on six months old rough lemon rootstock (R_2T_2) which was followed (90%) by R_1T_8 (Sweet orange grafted on twelve months Rangpur lime rootstock) but minimum (56.67%) was recorded at R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) and preceded (70%) by R_2T_9 (Sweet orange scion

Table 1: Combined effect of rootstock and rootstock ages on days to bud break, graft success, graft survivability and plant height

Treatment		Days to bud break (days)	Graft success (%)	Graft survivability (%)	Plant height (after one year of grafting)(cm)
Rootstock	**Age**				
R_1	T_1	15.00^{d}	63.33^{d}	56.67	48.33
	T_2	12.00^{e}	100.00^{a}	86.67	58.58
	T_3	14.00^{d}	96.67^{ab}	86.67	60.17
	T_4	20.00^{c}	86.67^{abc}	73.33	54.08
	T_5	24.00^{a}	83.33^{bc}	73.33	63.00
	T_6	22.00^{b}	83.33^{bc}	73.33	52.18
	T_7	20.00^{c}	90.00^{abc}	83.33	49.70
	T_8	22.00^{b}	96.67^{ab}	90.00	49.00
	T_9	22.00^{b}	86.67^{abc}	76.67	49.42
R_2	T_1	12.00^{e}	86.67^{abc}	73.33	56.39
	T_2	12.00^{e}	96.67^{ab}	93.33	58.75
	T_3	15.00^{d}	90.00^{abc}	80.00	64.42
	T_4	25.00^{a}	95.00^{ab}	80.00	56.13
	T_5	21.00^{bc}	86.67^{abc}	73.33	49.50
	T_6	20.00^{c}	96.67^{ab}	86.67	48.83
	T_7	15.00^{d}	96.67^{ab}	86.67	54.42
	T_8	22.00^{b}	86.67^{abc}	80.00	53.39
	T_9	22.00^{b}	80.00^{c}	70.00	48.17
LSD(0.05)		**1.10**	**13.45**	**13.87**	**11.94**
Level of significance		*****	*****	**NS**	**NS**
CV%		**5.02**	**9.11**	**10.57**	**13.29**

*=significant at 5% level of probability, NS=Not Significant

Here, R_1=Rangpur lime rootstock, R_2=Rough lemon rootstock, T_1=Five months old rootstock, T_2=Six months old rootstock, T_3=Seven months old rootstock, T_4=Eight months old rootstock, T_5=Nine months old rootstock, T_6=Ten months old rootstock, T_7=Eleven months old rootstock, T_8=Twelve months old rootstock and T_9=Thirteen months old rootstock

grafted on thirteen months old rough lemon rootstock) (Table 1).

Combination of rootstocks and rootstock age had no significant effect on plant height of sweet orange grafts after one year of grafting. The tallest (64.42 cm) plant height was recorded for the effect R_2T_3 (Sweet orange scion grafted on seven months old rough lemon rootstock) and followed (63 cm) by R_1T_5 (Sweet orange scion grafted on nine months old Rangpur lime rootstock). The shortest (48.17 cm) height of plant was recorded for R_2T_9 (Sweet orange scion grafted on thirteen months old Rangpur lime rootstock) and preceded by (48.33 cm) R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) and R_2T_6 (Sweet orange scion grafted on ten months old rough lemon rootstock) (Table 1).

Combined effect on sweet orange rootstock diameter was significantly dissimilar. Maximum (9.37 mm) rootstock diameter was recorded when it was R_1T_3 (Sweet orange scion grafted on seven months old Rangpur lime rootstock) and followed (9.29 mm) by R_1T_9 (Sweet orange scion grafted on thirteen months old Rangpur lime rootstock). Minimum (4.9 mm) combined effect showed by R_1T_4 (Sweet orange scion grafted on eight months old Rangpur lime rootstock) for rootstock diameter and preceded (6.64 mm) by R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) (Table 2).

Table 2: Combined effect of rootstock and rootstock ages on rootstock diameter, scion diameter, number of leaves per plant, canopy volume, leaf area and relative water content

Treatment		Rootstock diameter (mm)	Scion diameter (mm)	Number of leaves/ plant	Canopy volume (m^3)	Leaf area (cm^2)	RWC (%)
Rootstock	**Age**						
R_1	T_1	6.64^{e}	6.06^{ef}	23.67	0.019	15.31^{cdefg}	85.86^{abcd}
	T_2	8.04^{abcd}	7.00^{abcdef}	50.67	0.029	19.95^{abc}	92.49^{abc}
	T_3	9.37^{a}	8.27^{ab}	51.67	0.038	24.27^{a}	84.88^{bcd}
	T_4	4.90^{f}	3.69^{g}	44.00	0.023	18.98^{abcde}	90.79^{abcd}
	T_5	8.80^{abc}	8.34^{ab}	44.00	0.038	15.41^{cdefg}	89.25^{abcd}
	T_6	8.68^{abc}	6.58^{cdef}	41.33	0.022	14.55^{defg}	69.48^{e}
	T_7	8.10^{abcd}	6.20^{def}	31.00	0.021	17.25^{bcdefg}	89.47^{abcd}
	T_8	7.55^{cde}	5.90^{f}	27.67	0.014	12.82^{g}	99.15^{a}
	T_9	9.29^{ab}	8.54^{a}	22.00	0.021	18.30^{bcdef}	97.21^{ab}
R_2	T_1	7.34^{de}	6.42^{def}	33.67	0.031	20.26^{abc}	78.35^{de}
	T_2	8.86^{abc}	7.58^{abcde}	54.00	0.033	18.41^{bcdef}	89.66^{abcd}
	T_3	8.91^{ab}	7.70^{abcd}	61.00	0.042	15.72^{cdefg}	95.61^{ab}
	T_4	7.98^{bcde}	6.73^{bcdef}	33.00	0.023	22.28^{ab}	80.73^{cde}
	T_5	7.98^{bcde}	8.43^{a}	44.00	0.023	13.76^{efg}	91.15^{abcd}
	T_6	8.72^{abc}	6.63^{cdef}	38.67	0.025	19.75^{abcd}	92.40^{abc}
	T_7	8.30^{abcd}	8.15^{abc}	36.67	0.031	18.29^{bcdef}	87.57^{abcd}
	T_8	8.04^{abcd}	6.31^{def}	22.00	0.020	13.25^{fg}	93.46^{abc}
	T_9	7.22^{de}	6.07^{ef}	25.33	0.021	18.33^{bcdef}	90.58^{abcd}
LSD(0.05)		**1.34**	**1.63**	**18.25**	**0.02**	**5.37**	**13.73**
Level of significance		*****	*****	**NS**	**NS**	*****	*****
CV%		**10.00**	**14.19**	**28.93**	**36.53**	**18.38**	**9.31**

* = significant at 5% level of probability, NS=Not Significant

Rootstocks and rootstock age collectively had significant effect on scion diameter. The widest (8.54 mm) scion diameter of sweet orange occurred when it was grafted on thirteen months old Rangpur lime rootstock (R_1T_9) which was statistically similar (8.4) to R_2T_5 (Sweet orange grafted on nine months old rough lemon rootstock) but the narrowest (3.69 mm) was for R_1T_4 (Sweet orange scion grafted on eight months old Rangpur lime rootstock) and preceded (5.9 mm) by R_1T_8 (Sweet orange scion grafted on twelve months old Rangpur lime rootstock) (Table 2). Perhaps cause of quick and tough development of unification between the rootstock and scion, consecutively inducing bigger absorption of nutrient elements by developed shoots.

Rootstocks and rootstock age collectively had no significant effect on number of leaves per plant (Table 2). the highest (61.00) number of leaves per plant of sweet orange occurred when it was grafted on seven months old rough lemon rootstock (R_2T_3) and followed (54.00) by R_2T_2 (Sweet orange grafted on six months old rough lemon rootstock) but the lowest (22.00) number of leaves per plant of Sweet orange was for R_2T_8 (Sweet orange scion grafted on twelve months old rough lemon rootstock) and R_1T_9 (Sweet orange scion grafted on thirteen months old Rangpur lime rootstock) preceded by (23.67) R_1T_1 (Sweet orange scion grafted on five month old Rangpur lime).

There were no statistical dissimilarities among the treatment combinations related to canopy volumes of sweet orange saplings as they were grafted on different ages' Rangpur lime and rough lemon of respectively. Combined effect R_2T_3 (Sweet orange scion grafted on seven months old rough lemon rootstock) showed the biggest (0.042 cm^3) canopy volume of sweet orange and followed (0.038 cm^3) by R_1T_3 and R_1T_5 but the smallest (0.014 cm^3) canopy volume was for R_1T_8 (Sweet orange

scion grafted on twelve months old Rangpur lime rootstock) (Table 2).

Remarkable variation was observed among the combined effect on sweet orange grafts' leaf area. The largest (24.27 cm^2) leaf area was produced by R_1T_3 (Sweet orange scion grafted on seven months old Rangpur lime rootstock) and followed (22.28 cm^2) by R_2T_4 (Sweet orange scion grafted on eight months old rough lemon rootstock) while the smallest (12.82 cm^2) leaf area was produced by R_1T_8 (Sweet orange scion grafted on twelve months old Rangpur lime rootstock) (Table 2). Larger leaf area may be due to satisfactory stock-scion collaboration which is succeeded through better root shoot indicating system and good scion physiology and thus upper shoot biomass gathering (Ali *et al.*,1996).

Combination of Rootstocks and rootstock age had significant effect on relative water content (RWC) of leaves of sweet orange grafts. The highest (99.15%) relative water content was recorded for the effect R_1T_8 (Sweet orange scion grafted on twelve months old Rangpur lime rootstock) and followed (97.21%) by R_1T_9 (Sweet orange scion grafted on thirteen months old Rangpur lime rootstock). The lowest (69.48%) relative water content of leaves of plant was recorded for R_1T_6 (Sweet orange scion grafted on ten months old Rangpur lime rootstock) and preceded (78.35%) by R_2T_1 (Sweet orange scion grafted on five months old rough lemon rootstock) (Table 2). Better water holding capacity of the grafts in different treatments may be due to improved water use efficacy which has straight relation with total vigor and biomass collection (Passioura, 1986).

Combination of Rootstocks and rootstock age had no significant effect on stem fresh weight of sweet orange grafts. The highest (32.38 g) stem fresh weight was recorded for the effect R_2T_3 (Sweet orange scion grafted on seven months old rough lemon rootstock) and followed (31.36 g) by R_2T_5 (Sweet orange scion grafted on nine months old rough lemon rootstock). The lowest (11.78 g) stem fresh weight of plant was recorded for R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) and preceded (14.79 g) by R_1T_8 (Sweet orange scion grafted on twelve months old Rangpur lime rootstock) (Table 3).

Rootstocks and rootstock age had no significant effect on root volume of sweet orange graft. The maximum (30.00 cm^3) root volume of sweet orange graft found when it was grafted on ten months old rough lemon rootstock (R_2T_6) which was followed (25.67 cm^3) by R_2T_3 (Sweet orange grafted on seven months old rough lemon rootstock) but the minimum (12.33 cm^3) was for R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) and preceded (13.33 cm^3) by R_1T_2 (Sweet orange scion grafted on six months old Rangpur lime rootstock) (Table 3).

Rootstocks and rootstock age had no significant combined effect on root fresh weight of sweet orange graft. The largest (28.58 g) root fresh weight of sweet orange graft found when it was grafted on nine months old rough lemon rootstock (R_2T_5) which was followed (25.29 g) by R_2T_3 (Sweet orange grafted on seven months old rough lemon rootstock) but the smallest (9.42 g) was recorded at R_1T_1 (Sweet orange scion grafted on five months old Rangpur lime rootstock) and preceded (10.45 g) by R_1T_2 (Sweet orange scion grafted on six months old Rangpur lime rootstock) (Table 3).

No significant variation was observed among the combined effect on root: shoot ratio of sweet orange grafts. Maximum (1.05) root to shoot ratio was recorded at R_2T_9 (Sweet orange scion grafted on thirteen months old rough lemon rootstock) and followed (0.94) by R_1T_9 (Sweet orange scion grafted on thirteen months old Rangpur lime rootstock) while minimum (0.45) root to shoot was recorded at R_1T_2 (Sweet orange scion grafted on six months old Rangpur lime rootstock) and preceded (0.55) by R_1T_5 (Sweet orange scion grafted on nine months old Rangpur lime rootstock) (Table 3).

Combined effect on total chlorophyll of sweet orange grafts was significantly dissimilar. The highest (1.44 mg/g tissue) total chlorophyll was recorded in treatment combination of R_1T_4 (Sweet orange scion grafted on eight months old Rangpur lime rootstock), R_2T_3 (Sweet orange scion grafted on seven months old rough lemon rootstock) and R_2T_4 (Sweet orange scion grafted on eight months old rough lemon rootstock) while it was statistically similar (1.43 mg/g tissue) to R_2T_9 (Sweet orange scion grafted on thirteen months old rough lemon rootstock). The lowest (1.12 mg/g tissue) total

Table 3: Combined effect of rootstock and rootstock ages on stem fresh weight, root volume, root fresh weight, root: shoot ratio and total chlorophyll

Treatment		Stem fresh	Root volume	Root fresh	Root: Shoot	Total chlorophyll
Rootstock	**Age**	**weight(g)**	**(cm^3)**	**weight(g)**	**ratio**	**(mg/g tissue)**
R_1	T_1	11.78	12.33	9.42	0.70	1.41^{ab}
	T_2	19.37	13.33	10.45	0.45	1.41^{ab}
	T_3	28.98	25.00	22.96	0.63	1.40^{ab}
	T_4	19.14	19.67	16.55	0.59	1.44^{a}
	T_5	24.25	25.00	20.79	0.55	1.37^{abc}
	T_6	19.44	21.67	18.16	0.64	1.42^{ab}
	T_7	18.42	17.33	17.62	0.74	1.39^{abc}
	T_8	14.79	15.00	16.04	0.72	1.33^{bc}
	T_9	18.79	23.33	22.15	0.94	1.37^{abc}
R_2	T_1	19.18	17.00	14.37	0.64	1.40^{ab}
	T_2	26.95	19.67	22.42	0.64	1.36^{abc}
	T_3	32.38	25.67	25.29	0.60	1.44^{a}
	T_4	22.07	21.33	19.63	0.58	1.44^{a}
	T_5	31.36	20.00	28.58	0.65	1.30^{c}
	T_6	26.96	30.00	24.57	0.71	1.39^{abc}
	T_7	19.21	18.00	15.58	0.67	1.35^{abc}
	T_8	18.76	22.67	18.93	0.72	1.12^{d}
	T_9	15.19	19.67	17.24	1.05	1.43^{a}
LSD(0.05)		**7.37**	**8.65**	**9.84**	**0.26**	**0.099**
Level of significance		**NS**	**NS**	**NS**	**NS**	*****
CV%		**20.66**	**25.58**	**31.32**	**22.96**	**4.34**

* = significant at 5% level of probability, NS=Not Significant

chlorophyll was recorded by R_2T_8 (Sweet orange scion grafted on twelve months old rough lemon rootstock) and preceded by (1.30 mg/g tissue) by R_2T_5 (Sweet orange scion grafted on nine months old rough lemon rootstock) (Table 3). The greater chlorophyll content observed in the leaves of different treatments certified to the better stock-scion collaboration lead to improved capture and assimilation of light, consumption of water and nutrient elements which overall enriched the leaves of grafted scion's photosynthesis ability and biomass making (Deshmukh *et al*., 2017).

CONCLUSION

From above outcomes it was found that R_2T_3 (Sweet orange scion grafted on seven months old Rough lemon rootstock) was preferable for achieving better planting materials, among the combined effects as it gave the highest results in respect of plant height, number of leaves per plant, stem fresh weight and total chlorophyll. R_2T_3 (Sweet orange scion grafted on seven months old Rough lemon rootstock) showed also 80% graft survivability after one year of grafting.

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