

Stionic relationship among three citrus species using cleft grafting

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ARTICLE INFO

Article history

Accepted 13 May 2017

Online release 30 May 2017

Keyword

Stionic relationship

Cleft grafting

Citrus

Lime

Lemon

Pumelo

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ABSTRACT

The present experiment was carried out to investigate the effect of rootstocks on the success, survivability and growth of cleft grafted different citrus species at the Germplasm Centre of the Fruit Tree Improvement Program (FTIP). Bangladesh Agricultural University, Mymensingh during the period from August, 2010 to October, 2011. The experiment consisted of three different citrus species as Kagji Lebu (*Citrus aurantifolia*), Elachi Lebu (*Citrus limon*) and Pumelo (*Citrus grandis*). Graft combinations of each other were considered as treatments of the experiment. The two-factor experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Significant variations were found among the grafts with respect to most of the parameters studied. Rootstock of pumelo required maximum time for bud break (23.78 days), leaf opening (25.78 days) and produced the highest number of branches (1.65), leaves (3.87) with the highest graft success (99.82%) and survivability (99.40%) whereas, the rootstock of lime took minimum time for bud break (21.10 days) and leaf opening (23.18 days) and produced the lowest number of leaves (2.43). But the rootstock of lemon contributed to the development of the highest graft height (9.43cm) with the lowest branch number (0.64), graft success (99.09%) and survivability (97.08%). In respect of effect of scion the pumelo needed maximum time to bud breaking (23.67 days) and leaf opening (25.58 days) and produced the highest branch number (2.34), leaf number (25.35) as well as canopy volume (138.64cm³) with the maximum graft success (99.83%) and survivability (99.20%). On the other hand scion of lime took minimum time to bud break (21.02 days), leaf opening (23.11 days) and produced the lowest leaf number (16.39) and canopy volume (122.14cm³). But the scion of lemon contributed to the highest graft height (36.62cm) with the lowest graft success (99.15%) and survivability (97.12%). The combination of stock and scion of pumelo required maximum time to bud break (23.60 days), leaf opening (25.67 days) and produced the highest branch number (2.34), leaf number (39.18), canopy volume (149.73cm³), graft success (99.82%) and survivability (99.21%) with the lowest graft height (37.33cm). On the other hand the combination of stock and scion of lime needed minimum time to bud break (21.00 days), leaf opening (23.00 days) and produce the lowest leaf number (27.00) and canopy volume (127.11cm³). But stock and scion combination of lemon contributed to the development of highest graft height (45.40cm) with the lowest branch number (0.58), graft success (99.02%) and survivability (97.05%). From the above results it may be concluded that the rootstock and scion of pumelo had remarkable effect on the highest graft success and survivability with dwarf plant of large canopy. But rootstock of lemon had influence to produce tall plant.

INTRODUCTION

Citrus is a genus of flowering plants in the family Rutaceae and a common name for edible fruits of this genus. Originating in tropical and subtropical Southeast Asia, these plants are among the oldest fruit crops to be domesticated (Katz and Weaver, 2003). Citrus fruits are a distinctive berry with the internal parts divided into segments and include oranges, lemons, limes, citrons, grapefruit, pomelos and mandarins (tangerines). Citrus is likely the most widely planted fruit for direct human consumption in the world (Katz and

Weaver, 2003). In Bangladesh citrus as lime, lemon and pumelo grow everywhere and these fruits have a demand among all classes of people. According to the available statistics, the total area under these fruits is 4567 acres while total production is 5594 M. tons in the year 2008-09 (BBS, 2009). Lime, lemon and pumelo are good sources of different vitamins and minerals. It is observed that 93% of people of Bangladesh are suffering from deficiency of vitamin C. (Anonymous, 1980). All such malnutrition problems could have been reduced considerably if the people of Bangladesh would have adequate

access of fruits, especially citrus fruits which are generally known to be rich in these vitamins and minerals. Citrus has also some medicinal value (Reuther et al., 1968). But citrus fruits are decreasing day by day for lack of proper care and knowledge. To define the way of successful propagation and effective conservation of these fruits, very few research works have been performed before. Cleft grafting is one of the simplest, oldest and most popular methods of grafting in Bangladesh. There is the influence of root stock on scion and vice-versa. The rootstock exerts a marked effect on the growth habit, flowering, fruiting and ultimately the yield of the graft. The size of tree can be controlled by using specific rootstocks. It is easy, less time consuming and it requires less skill. A number of factors influence the performance of cleft grafting. Among these, proper handling, high humidity, low temperature, optimum mineral nutrition and selection of scion and rootstock are important. Information regarding the influence of rootstock on scion and vice-versa in citrus species is inconclusive. Considering the above facts in mind, the present piece of research work was undertaken to study the effect of rootstock on scion and scion on rootstock on the success, survivability and growth of cleft grafts in three species of citrus with the following objectives:

- to find out the effect of different citrus rootstocks on the success, survivability and growth of grafts;
- to know the influence of different citrus scions on the success, survivability and growth of grafts; and
- to select suitable rootstock for having desired size and shape of plants.

MATERIALS AND METHODS

The present experiment was carried out to investigate the effect of rootstocks on the success, survivability and growth of cleft grafted different citrus species at the Germplasm Centre of the Fruit Tree Improvement Program (FTIP), Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from August, 2010 to October, 2011. The experiment consisted of three different citrus species as Kagji Lebu (*Citrus aurantifolia*), Elachi Lebu (*Citrus limon*) and Pumelo (*Citrus grandis*). Graft combinations of each other were considered as treatments of the experiment. The two-factor experiment was laid

out in a Randomized Complete Block Design (RCBD) with 3 replications. Experimental materials were rootstocks of lime, lemon, pumelo and scions of lime (year round), lemon (semi seedless), pumelo (BAU-2). The rootstocks used in the experiment were raised in the polybag from the lime, lemon, pumelo seeds of unknown variety. The scion shoots used, were collected from the mother plants of lime (year round), lemon (semi seedless) and pumelo (BAU-2) grown in the Germplasm Centre of Fruit Tree Improvement Program (FTIP), Bangladesh Agricultural University, Mymensingh-2202. The rootstock was at first deheaded at semi-matured point by giving slanting cut and then a vertical split cut was made by a thin and sharp bladed grafting knife at the center of the slanting cut surface of the stock having a depth of approximately 3-4 cm. All necessary measures were adopted to keep the polybags free from weeds and create a favorable condition to ensure proper growth and development of the grafted plants. Weeding, mulching and irrigation were done whenever necessary during the period of investigation. Data regarding days required to bud break, first flush of leaf and first leaf opening, length of rootstock and scion, leaf number, branch number, length and breadth of the longest leaf, graft height, diameters of rootstock and scion, canopy volume, percentages of graft success and survivability were recorded periodically and analyzed.

RESULTS AND DISCUSSION

The results obtained from the experimental data regarding percent success, days required to bud breaking, first flush, first leaf opening, number of leaves per graft, length of rootstock, diameter of rootstock, length of scion, diameter of scion, length of the longest leaf, breadth of the longest leaf, plant canopy volume and graft height have been presented in different figures and tables.

Main effect of rootstock

Significant variations were observed on success and other parameters due to the effect of rootstocks. The highest success (99.82%) and survivability (99.40%) were found in pumelo stock while the lowest success (99.09%) and

survivability (97.08%) were found in lemon root stock (Table 1). Rootstock of lime required the shortest time to bud break (21.10 days), first leaf flushing (22.09 days) and first leaf opening (23.18 days) while the rootstock of pumelo required the highest time to bud break (23.78 days), first leaf flushing (24.42 days) and leaf opening (25.78 days). Rootstock of lemon showed the highest scion length (36.17 cm) and graft height (9.43 cm) while the rootstock of pumelo showed the lowest scion length (29.05 cm) and graft height (8.31 cm) (Table 1 and 2). Rootstock of pumelo gave the highest diameter of rootstock and scion (0.70 cm and 0.55 cm) respectively, number of leaf (3.87 leaves), number of branch (1.65 branches), length of the longest leaf (6.95 cm) and canopy volume (108.19cm²) while the rootstock of lime gave the lowest diameter of rootstock and scion(0.58cm and 0.45 cm) respectively, number of leaves (2.43 leaves), number of branches (0.64 branches), length of the longest leaf (4.60 cm) and canopy volume (98.00 cm²) (Table 1- 2).

Rootstocks significantly influenced on the increased graft height at 30 to 120 DAG. The highest (9.43 cm) and the lowest (8.31 cm) graft height were recorded due to the effect of rootstocks of lemon and pumelo respectively (Figure 1).

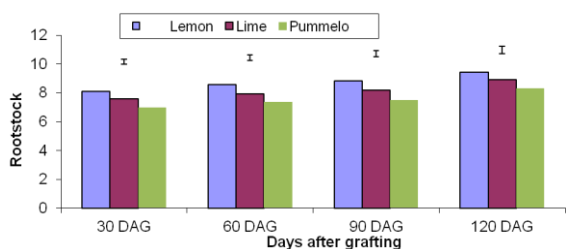


Figure 1
Main effect of rootstock on the graft height (cm). Vertical bars represent LSD at 1% level of probability.

Main effect of scion:

Due to the effect of scion significant variations were also observed on success, survivability and growth of graft. The highest graft success (99.83%) and survivability (99.20%) were found due to the influence of pumelo scion and the lowest success (99.15%) and survivability

(97.12%) were found in scion of lemon. Scion of lime required the shortest time to bud break (21.02 days), first leaf flushing (22.22 days) and leaf opening (23.11 days) while the scion of pumelo required the highest time to bud break (23.67 days), first leaf flushing (24.42 days) and first leaf opening (25.58days) (Table 3).

Scion of lemon showed the highest rootstock length (9.43 cm) and graft height (36.62 cm) while the scion of pumelo showed the lowest rootstock and scion length (8.31 cm and graft height (31.75 cm). Scion of pumelo influenced on the highest diameters of rootstock and scion (0.69 cm and 0.63 cm)respectively, number of leaves (25.35), number of branches (2.34), length and breadth of the longest leaves (6.93 cm and 4.96cm) respectively and canopy volume (143.25 cm³) while the scion of lime showed the lowest diameter of rootstock and scion (0.59 cm and 0.50 cm) respectively, number of leaves (16.39), number of branches (1.23) ,length and breadth of the longest leaf (4.27 cm and 4.09cm) respectively and canopy volume (132.14 cm³) (Tables 3-4).

Scions significantly influenced on the increased graft height at 30 to 120 DAG. The highest (36.62 cm) and the lowest (31.75 cm) increased graft height were recorded due to the effect of scions of lemon and pumelo at 120 DAG (Figure 2).

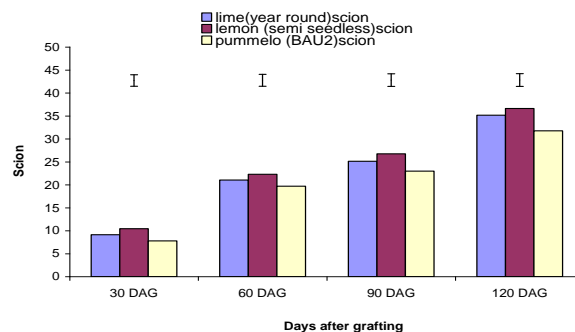


Figure 2
Main effect of scion on the graft height (cm). Vertical bars represent LSD at 1% level of probability.

Table 1

Main effect of rootstock on the days required to bud break, days required to 1st flush, days required to 1st leaf opening, % graft success, % graft survivability, number of leaves per graft, number of branches and rootstock diameter at 30, 60, 90 and 120 DAG.

Treatments	Days required to bud break	Days required to 1st flush	Days required to 1 st leaf opening	% Graft success	% Graft survivability	Number of leaves at DAG				Number of branches at DAG				Rootstock diameter at DAG			
						30	60	90	120	30	60	90	120	30	60	90	120
Rootstock of lime	21.10	22.09	23.18	99.39	97.49	1.27	1.60	2.04	2.43	0.34	0.51	0.73	0.92	0.38	0.46	0.51	0.58
Rootstock of lemon	21.27	22.56	23.41	99.09	97.08	1.39	1.95	2.58	2.90	0.15	0.30	0.49	0.64	0.42	0.51	0.57	0.65
Rootstock of pumelo	23.78	24.42	25.78	99.82	99.40	1.03	2.39	2.93	3.87	0.64	0.91	1.20	1.65	0.45	0.54	0.61	0.70
LSD at 5%	1.062	1.652	1.903	0.005	1.316	0.43	0.91	0.012	0.024	0.22	0.39	0.46	0.64	0.01	0.01	0.02	0.03
LSD at 1%	1.176	2.024	2.025	0.057	2.041	0.59	0.63	0.75	0.96	0.38	0.55	0.67	0.82	0.02	0.03	0.04	0.05
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

DAG= Days after grafting

Table 2

Main effect of rootstock on the scion length, scion diameter, length of the longest leaf and canopy volume at 30, 60, 90 and 120 DAG.

Treatments	Scion length at DAG				Scion diameter at DAG				Length of the longest leaf at DAG				Canopy volume at DAG			
	30	60	90	120	30	60	90	120	30	60	90	120	30	60	90	120
Rootstock of lime	9.14	20.31	25.74	32.62	0.28	0.35	0.40	0.45	2.98	3.54	3.98	4.60	73.34	81.06	91.48	98.00
Rootstock of lemon	10.46	22.03	27.72	36.17	0.30	0.38	0.44	0.48	3.45	4.12	4.96	5.47	80.63	87.89	95.37	102.85
Rootstock of pumelo	7.79	19.69	22.99	29.05	0.32	0.40	0.48	0.55	3.94	4.83	5.11	6.95	90.19	95.12	100.66	108.19
LSD at 5%	0.13	1.204	1.27	1.35	0.01	0.03	0.04	0.05	0.17	0.26	0.371	0.432	4.498	4.635	5.621	6.783
LSD at 1%	1.25	1.307	1.36	1.38	0.03	0.05	0.05	0.06	0.24	0.36	0.434	1.628	6.206	6.405	7.449	8.868
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; DAG= Days after grafting

Table 3

Main effect of scion on the days required to bud break, days required to 1st flush, days required to 1st leaf opening, % graft success, % graft survivability, number of leaves per graft, number of branches and rootstock diameter at 30, 60, 90 and 120 DAG.

Treatments	Days required to bud break	Days required to 1st flush	Days required to 1 st leaf opening	% Graft success	% Graft survivability	Number of leaves at DAG				Number of branches at DAG				Rootstock diameter at DAG			
						30	60	90	120	30	60	90	120	30	60	90	120
Rootstock of lime	21.02	22.22	23.11	99.42	97.45	5.64	9.65	11.14	16.39	0.57	0.71	0.93	1.47	0.41	0.48	0.53	0.59
Rootstock of lemon	21.26	22.40	23.56	99.15	97.12	6.59	11.26	15.36	20.96	0.33	0.50	0.79	1.23	0.44	0.51	0.58	0.63
Rootstock of pumelo	23.67	24.42	25.58	99.83	99.20	5.16	14.24	20.88	25.35	0.95	1.48	1.81	2.34	0.46	0.52	0.60	0.69
LSD at 5%	1.077	1.576	1.717	1.585	1.538	0.43	1.91	2.09	2.53	0.43	0.57	0.69	0.80	0.00	0.03	0.03	0.04
LSD at 1%	1.197	2.345	2.039	2.184	2.120	1.60	2.34	2.67	2.98	0.56	0.73	0.84	0.96	0.01	0.04	0.04	0.05
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

DAG= Days after grafting

Table 4

Main effect of scion on the scion length, scion diameter, length of the longest leaf and canopy volume at 30, 60, 90 and 120 DAG.

Treatments	Scion length at DAG				Scion diameter at DAG				Length of the longest leaf at DAG				Canopy volume at DAG			
	30	60	90	120	30	60	90	120	30	60	90	120	30	60	90	120
Rootstock of lime	10.80	20.05	25.50	32.22	0.26	0.39	0.42	0.50	2.95	3.32	3.87	4.27	99.08	108.93	120.44	132.14
Rootstock of lemon	12.90	23.62	28.61	36.57	0.29	0.42	0.49	0.57	3.23	4.17	4.83	5.15	101.44	112.85	125.79	138.64
Rootstock of pumelo	8.16	20.10	25.11	29.45	0.31	0.45	0.55	0.63	3.75	4.90	5.47	6.93	105.36	112.85	125.79	138.64
LSD at 5%	0.42	1.16	1.39	1.79	0.03	0.04	0.05	0.06	0.19	0.27	0.38	0.54	4.509	4.654	5.630	6.796
LSD at 1%	0.58	1.37	1.50	1.92	0.04	0.05	0.06	0.08	0.26	0.37	0.54	1.73	6.212	6.412	7.757	8.875
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability

DAG= Days after grafting

Table 5

Combined effect of rootstock and scion on the days required to bud break, days required to 1st flush, days required to 1st leaf opening, % graft success and % graft survivability number of leaves per graft, number of branches and length of rootstock at 30, 60, 90 and 120 DAG.

Combined treatments		Days required to			% Graft success	% Graft survivability	Number of leaves at DAG				Number of branches at DAG				Diameter of rootstock at DAG			
Root stock	Scion	bud break	first flush of leaf	first leaf opening			30	60	90	120	30	60	90	120	30	60	90	120
Lime	Lime (year round)	21.0	21.00	22.3	23.0	99.4	98.	17.1	24.64	27.00	0.34	0.51	0.73	0.58	0.41	0.45	0.50	0.57
	Lemon (semi seedless)	21.2	21.20	22.5	23.2	99.1	97.64	19.3	26.70	31.70	0.15	0.30	0.49	0.64	0.45	0.46	0.51	0.58
	Pumelo (BAU-2)	23.0	23.00	24.0	25.3	99.7	99.0	21.4	33.88	38.05	0.54	1.24	1.60	2.15	0.45	0.46	0.51	0.58
Lemon	Lime (year round)	21.1	21.10	22.5	23.2	99.2	97.5	17.1	24.14	27.13	0.30	0.48	0.82	0.95	0.44	0.47	0.54	0.63
	Lemon (semi seedless)	21.3	21.35	22.6	23.6	99.0	97.0	19.5	26.81	31.49	0.13	0.28	0.42	0.92	0.41	0.47	0.54	0.64
	Pumelo (BAU-2)	23.2	23.20	24.4	25.5	99.7	99.0	21.8	33.86	38.81	0.57	1.36	1.75	2.16	0.45	0.47	0.53	0.64
Pumelo	Lime (year round)	21.3	21.37	22.6	23.5	99.4	98.6	18.6	25.64	28.03	0.37	0.71	0.93	1.47	0.41	0.49	0.57	0.69
	Lemon (semi seedless)	21.6	21.67	22.4	23.4	99.1	98.2	20.9	27.57	32.70	0.13	0.50	0.79	1.23	0.39	0.49	0.57	0.69
	Pumelo (BAU-2)	23.6	23.60	24.6	25.6	99.82	99.2	22.5	34.88	39.18	0.60	1.48	1.81	2.34	0.46	0.50	0.58	0.70
LSD at 5%		1.38	1.22	1.38	1.69	1.93	0.01	1.66	2.48	2.69	0.92	0.47	0.50	0.77	1.13	0.05	0.02	0.03
LSD at 1%		2.08	1.48	2.08	2.02	2.06	0.03	2.07	2.80	2.93	1.27	0.58	0.77	0.95	1.55	0.08	0.03	0.05
Level of significance		**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Table 6
Combined effect of rootstock and scion on the scion length, scion diameter and length of the longest leaf at 30, 60, 90 and 120 DAG.

Combined treatments		Length of scion at DAG				Scion diameter at DAG				Length of the longest leaf at DAG			
Rootstock	Scion	30	60	90	120	30	60	90	120	30	60	90	120
Lime	Lime (year round)	10.99	21.15	26.77	32.18	0.26	0.32	0.36	0.42	2.78	3.16	3.58	4.28
	Lemon (semi seedless)	11.38	23.49	29.53	35.10	0.29	0.40	0.40	0.50	3.50	4.29	5.06	5.49
	Pumelo (BAU-2)	8.54	20.52	25.73	30.13	0.30	0.39	0.43	0.56	3.95	4.50	5.49	6.43
Lemon	Lime (year round)	10.42	21.29	26.40	32.24	0.27	0.35	0.40	0.46	2.82	3.26	3.74	4.36
	Lemon (semi seedless)	11.17	23.11	29.56	35.82	0.28	0.36	0.41	0.51	3.45	4.19	5.10	5.89
	Pumelo (BAU-2)	8.21	20.14	25.35	30.11	0.31	0.40	0.45	0.54	3.86	4.51	5.69	6.49
Pumelo	Lime (year round)	10.41	21.05	26.21	32.44	0.28	0.36	0.41	0.48	2.80	3.43	3.91	4.52
	Lemon (semi seedless)	11.11	23.51	29.08	35.30	0.30	0.39	0.43	0.52	3.49	4.03	5.08	5.95
	Pumelo (BAU-2)	8.49	20.30	25.22	30.10	0.32	0.43	0.48	0.56	3.87	4.60	5.82	6.93
LSD at 5%		0.738	1.358	2.103	2.310	0.045	0.057	0.067	0.79	0.603	0.328	0.474	0.582
LSD at 1%		2.248	2.248	3.613	3.632	0.065	0.073	0.084	0.98	0.852	0.452	0.653	0.742
Level of significance		**	**	**	**	**	**	**	**	**	**	**	**

Table 7
Combined effect of rootstock and scion on the breadth of the longest leaf, graft height and canopy volume at 30, 60, 90 and 120 DAG.

Combined treatments		Breadth of the longest leaf at DAG				Graft height at DAG				Canopy volume at DAG			
Rootstock	Scion	30	60	90	120	30	60	90	120	30	60	90	120
Lime	Lime (year round)	1.42	2.17	3.09	4.08	17.38	28.49	31.77	43.38	98.00	100.20	111.97	127.11
	Lemon (semi seedless)	1.57	2.28	3.38	4.84	19.99	30.15	34.53	45.10	101.42	117.36	126.89	138.15
	Pumelo (BAU-2)	1.81	2.55	3.58	4.95	15.54	25.52	30.73	41.53	96.67	120.61	130.57	142.53
Lemon	Lime (year round)	1.46	2.18	3.07	4.09	18.97	29.95	35.21	43.14	98.82	105.14	112.01	128.87
	Lemon (semi seedless)	1.54	2.30	3.35	4.83	19.42	30.11	36.56	45.40	100.28	116.31	127.73	135.15
	Pumelo (BAU-2)	1.86	2.52	3.54	4.91	15.21	25.14	30.35	41.11	97.46	120.22	130.37	146.53
Pumelo	Lime (year round)	1.45	2.12	3.03	4.11	17.91	29.29	32.40	43.24	98.51	102.44	110.34	127.24
	Lemon (semi seedless)	1.44	2.26	3.34	4.84	17.31	28.51	34.08	45.20	100.37	112.88	124.76	137.63
	Pumelo (BAU-2)	1.89	2.53	3.56	4.95	14.49	20.30	29.22	37.33	94.12	122.04	132.87	149.70
LSD at 5%		0.574	0.277	0.390	0.455	1.610	1.103	1.230	1.485	12.699	7.810	8.060	9.751
LSD at 1%		0.791	0.457	0.556	0.713	2.832	2.071	2.251	2.613	18.764	110.760	11.105	13.435
Level of significance		**	**	**	**	**	**	**	**	**	**	**	**

Combined effect of rootstock and scion

The interaction effects as well as the combined effects of rootstock & scion demonstrated on the highest graft success (99.82%) and survivability (99.21%) in rootstock and scion of pumelo combination while the lowest success (99.02%) and survivability (97.05%) were in rootstock and scion of lemon combination. The minimum time required to bud break (21.00 days), first leaf flushing (22.33 days) and leaf opening (23.00 days) were in rootstock and scion of lime combination while the maximum time required to bud break (23.60 days), first leaf flushing (24.65 days) and leaf opening (25.67 days) were in rootstock and scion combination of pumelo combination (Table 5).

The highest graft height (45.40 cm), length of scion (35.82 cm) respectively were observed in rootstock and scion of lemon combination while the lowest graft height (37.33 cm), length of scion (30.10 cm) were observed in rootstock and scion of pumelo combination. The highest number of leaves (39.18), number of branches (2.34), length and breadth of the longest leaf (6.93 cm and 4.95 cm) respectively and canopy volume (149.70 cm³) were observed in rootstock and scion of pumelo combination while the lowest number of leaves (27.00), number of branches (0.58), length and breadth of the longest leaf (4.28 cm and 4.08 cm) respectively and canopy volume (127.11 cm³)

were observed in rootstock and scion of lime (Tables 5-7).

CONCLUSION

From the results as presented above it may be concluded that among the three species of citrus, rootstock of pumelo has remarkable effect on the highest graft success and survivability with dwarf plant with large canopy.

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