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Evaluation of Acid Lime (*C. aurantifolia* Swingle) on different Rootstocks in central India

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INTRODUCTION

Rootstocks affect over 20 citrus tree characteristics, primarily horticultural and pathological with certain aspect of propagation being common to all rootstocks. The potent effects of rootstock on the growth and fruiting of trees are widely recognized. Rootstock selection is a major consideration while planning any citrus and orchard. It is a fundamental to the success of the orchards, since the rootstock chosen, will become the part of root system of budded trees. Prolonged juvenility is undesirable in citrus is the major constraint to enforce potential productivity. The performance of scion cultivars and is affected in several ways by budding onto selected rootstocks. These are early fruiting and avoidance of juvenility problems, uniform tree size, cropping and fruit quality control, tolerance to unfavourable soil factors such as salinity, high pH and poor drainage and tolerance to *Phytophthora,* parasitic nematodes and viruses

Acid limes are traditionally raised through seedling in the country. However, given the limiting growing conditions that are replete with various biotic and abiotic stresses during the growth period of acid limes, it has become imperative to search for the proper rootstock that will impart good horticultural attributes as well as resistance to various stresses. The rootstock and various nutrients influence the growth yield and quality of fruits, which in turn is affected by nutrient availability on their absorbing capacity (Srivastava *et al.*,1994). Cultivars budded on Alemow grew well on both sandy and calcareous soil having high pH, produces vigorous and high yielding trees under different agro climatic conditions (Castle, 1987 and Sonkar *et al.* 2010). It is also reported to have high adaptability to cool dry climate, foot rot tolerant than true lemon (Carpenter *et al.* 1981) excellent and classical rootstock for mandarin, limes and lemons in other countries. A large number of citrus rootstocks are available overseas while, the Indian citrus industry has traditionally used only rough lemon and Rangpur lime rootstocks. A good rootstock provides the growers a useful tool to manipulate the vigour and performance of orchards trees. In the pursuit of finding out a suitable rootstock for acid lime, field trials on long term basis were initiated during 1992-93 at the Experimental farm of the Centre. The experiment consisted 20 rootstocks for acid lime was evaluated. The results below are presented for the period 2003- 09.

MATERIALS AND METHODS

The trial was laid out using 19 rootstocks an acid lime seedling including an exotic rootstock Alemow (*Citrus macrophylla*) at a distance of 5 × 5m with single tree unit each replicated four times in Randomized block design. The observation on tree height, spread of the trees (expressed as canopy volume) and girth of stock and scion 5 cm below and above the bud union were recorded during the month of December. Leaf samples collected from non-bearing shoots were subjected to analyse for macro and micro nutrients. The initial orchard soil was clayey with moderately deep varying from 35-45 cm, pH of 7.5, $CaCO_3$ range of 5.5-8.1%, available N 116.5 ppm, P 15.6 ppm and K 180 ppm. All the plants were supplied recommended dose of macro and micronutrients through soil application. The yield data were recorded both in number count and weight of fruit basis. Total soluble solids in juice were measured with hand refractometer, acidity by titration following the procedure of Ranganna (1986) and ascorbic acid estimation was done by titration by using 2,6- dichlorophenol-indophenol dye (AOAC,1984).

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RESULTS AND DISCUSSION

The study revealed that the plant growth parameters were influenced by various rootstocks. The acid lime seedlings proved to be the most vigorous in respect of plant height and canopy volume in comparison to those plants raised on rootstocks indicating vigorous growth habit (Table 1). The maximum tree spread of acid lime seedlings were also noticed by Rao *et al*.(1970). The highest fruit yield (13.4 t/ha) was recorded with Alemow, whereas seedling produced only 5.88 t/ha on cumulative yield basis (Table 1). Similar results were also reported in various citrus species like old line temple mandarin (Levy *et al*., 1980), Kinnow mandarin (Raj *et al*., 1995) and acid lime (Sonkar *et al*., 2004, Sonkar *et al*., 2012). The juice content and acidity were maximum than seedling trees and with rest of the rootstocks. The number of seeds per fruit were found to be lower (2.09 seeds/ fruit) in the fruit sampled from Chase rough lemon than the seedlings. Similar trend in acid lime also reported by Sonkar *et al.* (1999) and Sonkar *et al.* (2004).

Nutrient uptake pattern by scion of acid lime showed a significant response on the concentration of different nutrient except Cu. The responses on accumulation pattern of individual nutrient was clearly discernible with the type of rootstocks including seedlings used in combination with scion of acid lime as the trend was observed with Nagpur mandarin. Rootstock displayed a differential

Table1: Effect of rootstock strains on growth, yield and fruit quality of acid lime.

Rootstocks		Canopy Spread (m^3)	Yield (t/ha)	Juice content (%)	Acid content (%)	Fruit weight (g)	Rind thickness (mm)	No. of Seeds / fruit
1.	Chase rough lemon	108.1	1.731	43.12	5.50	29.51	1.33	2.09
2.	Rangpur lime (Brazilian)	92.9	2.09	35.65	5.93	28.62	1.43	3.60
3.	Rangpur lime (Texas)	95.3	2.82	40.15	5.87	29.48	1.3	3.03
4.	Cleopatra mandarin (Tirupati)	42.6	1.217	33.84	6.37	24.03	1.30	3.18
5.	Cleopatra mandarin (Coorg)	31.9	3.72	34.63	6.64	24.87	1.38	3.01
6.	Cleopatra mandarin (Grabstan)	40.9	2.224	36.22	5.30	28.80	1.3	4.46
7.	Cleopatra mandarin (Narayana)	38.5	4.651	35.17	5.13	25.92	1.28	2.72
8.	Cleopatra mandarin (Morocco)	46.5	3.717	36.67	5.98	27.44	1.27	3.81
9.	Cleopatra mandarin (Gonicoppal)	48.3	2.061	36.91	5.32	26.6	1.27	3.03
10.	Troyer Citrange (Chethalli)	62.8	5.755	37.30	4.82	26.93	1.35	4.52
11.	Troyer Citrange (Gonicoppal)	51.7	3.705	36.75	6.02	27.76	1.38	3.31
12.	Carrizo Citrange (Chethalli)	41.1	2.706	36.36	6.74	27.35	1.41	2.77
13.	Sour orange	64.1	1.802	37.39	7.08	27.25	1.30	2.88
14.	Schaub rough lemon	75.4	3.172	36.01	5.4	32.20	1.52	3.24
15.	C-35	33.2	3.39	37.03	5.67	25.46	1.37	3.09
16.	C-32	65.6	2.742	36.17	6.65	30.57	1.30	3.30
17.	Sun Chu Sha	54.5	3.55	36.74	5.16	28.21	1.39	3.76
18.	Sekhwasha X rough lemon	74.3	2.981	34.71	5.72	27.67	1.45	2.92
19.	Alemow(*C. macrophylla*)	69.6	13.40	39.61	5.44	30.12	1.40	4.34
20.	Acid lime (Seedling)	74.6	5.88	35.63	4.51	30.82	1.42	8.70
	CD 0.05	10.03	3.51	NS	NS	4.31	NS	0.92

nutrient accumulation pattern, with respect to nutrients in Alemow rootstock (2.2% N, 0.12% P, 1.21% K, 103ppm Fe, 57ppm Mn and 22ppm Zn) and imparted maximum concentration of different nutrients in leaves of acid lime than acid lime seedling trees (Table 2). This observation corroborate the finding of Levy *et al*. (1993) and Marathe *et al.* (2000). This was possibly due to strong extraction capacity of rootstock. The minimum incidence of citrus canker on leaves and fruits was noticed with Alemow, whereas the seedling trees showed maximum infestation. The nematode population was recorded minimum with Troyer Citrange (Gonicoppal) whereas canker infestation on leaves was recorded lower with Cleopatra mandarin (Morocco). The plants budded on Alemow resulted 100% survival after 18th year of its life span with excellent canopy and yield potential (Table 3).

The studies hence, suggested Alemow (C. *macrophylla* Wester, an old Philippine lemon/ pummelo hybrid) as a classical rootstock possessing outstanding traits as the most potent rootstock for acid lime with maximum nutrient extraction capacity and tree survival. It will go a long way in imparting not only production sustainability but improved orchard life as well, in addition to fitting this rootstock under high density orchard.

Table 2: Effect of rootstock strains on nutrient uptake and tree survival of acid lime.

Rootstocks		*N (%)*	*P (%)*	*K (%)*	*Fe (ppm)*	*Mn (ppm)*	*Cu (ppm)*	*Zn (ppm)*
1.	Chase rough lemon	1.82	0.10	0.87	71.67	40.07	6.67	18.20
2.	Rangpur lime (Brazillian)	1.76	0.09	0.70	78.30	33.97	5.93	15.57
3.	Rangpur lime (Texas)	1.77	0.10	0.65	69.87	38.40	5.63	17.23
4.	Cleopatra mandarin (Tirupati)	1.75	0.08	0.72	57.93	34.47	6.00	15.40
5.	Cleopatra mandarin (Coorg)	1.77	0.07	0.72	58.03	35.30	6.37	15.93
6.	Cleopatra mandarin (Grabstan)	1.69	0.08	0.68	71.47	32.03	10.17	15.67
7.	Cleopatra mandarin (Narana)	1.78	0.08	0.71	64.53	37.83	10.60	15.33
8.	Cleopatra mandarin (Morocco)	1.57	0.08	0.70	59.93	37.87	7.70	15.63
9.	Cleopatra mandarin (Gonicoppal)	1.69	0.08	0.68	58.90	34.67	6.73	14.80
10.	Troyer citrange (Chethalli)	1.65	0.08	0.72	66.93	35.07	7.50	14.37
11.	Troyer citrange (Gonicoppal)	1.71	0.08	0.66	55.00	36.07	6.43	14.90
12.	Carrizo citrange (Chethalli)	1.72	0.07	0.72	71.83	35.73	7.40	14.03
13.	Sour orange	1.82	0.08	0.80	71.10	41.57	8.60	16.23
14.	Schaub rough lemon	1.86	0.09	0.77	61.23	41.13	8.77	15.73
15.	C-35	1.68	0.08	0.67	76.87	36.70	7.87	15.00
16.	C-32	1.68	0.08	0.79	79.37	38.57	7.17	14.87
17.	Sun Chu Sha	1.95	0.08	0.70	77.60	41.63	8.67	15.30
18.	Sekhwasha X rough lemon	2.01	0.10	0.89	99.03	41.67	8.20	17.00
19.	Alemow(*C. macrophylla*)	2.20	0.12	1.21	103.17	56.47	9.37	21.67
20.	Acid lime (Seedling)	1.76	0.09	0.76	44.83	33.93	7.67	14.90
	CD 0.05	0.10	0.01	0.23	0.01	4.37	NS	1.55

Table 3: Effect of rootstock strains on nematode population, canker intensity and tree Survival of acid lime

	Rootstocks	*Soil nematode population (/100cc)*	*Root nematode population (/g)*	*No. of diseased leaves (%)*	*No. of fruits with canker (%)*	*Tree survival (%)*
1.	Chase rough lemon	1733.3	137.3	57.75	51.5	100
2.	Rangpur lime (Brazilian)	1194.3	84.7	45.1	44.7	75
3.	Rangpur lime (Texas)	1064.0	121.2	42.5	31.15	100
4.	Cleopatra mandarin (Tirupati)	946.7	108.3	37.45	27	50
5.	Cleopatra mandarin (Coorg)	864.3	118.0	34.2	36	75
6.	Cleopatra mandarin (Grabstan)	1528.3	128.7	28.95	16.95	100
7.	Cleopatra mandarin (Narayana)	1603.3	127.7	34.9	32.55	100
8.	Cleopatra mandarin (Morocco)	1158.2	99.3	23.55	17.85	75
9.	Cleopatra mandarin (Gonicoppal)	1295.0	88.7	25.65	24.95	100
10.	Troyer Citrange (Chethalli)	861.0	69.7	34.3	36.55	100
11.	Troyer Citrange (Gonicoppal)	767.3	64.5	31.75	27.95	75
12.	Carrizo Citrange (Chethalli)	1420.7	109.8	34.5	25.4	50
13.	Sour orange	1306.3	88.3	37.75	42.05	50
14.	Schaub rough lemon	921.3	119.0	67.55	50.25	75
15.	C-35	1163.3	122.3	45.25	33.2	75
16.	C-32	1198.3	92.7	42.55	35.85	50
17.	Sun Chu Sha	898.0	92.3	35.7	42.4	75
18.	Sekhwasha x rough lemon	989.3	79.0	64.05	54.5	100
19.	Alemow(*C. macrophylla*)	1222.5	99	41.35	31.5	100
20.	Acid lime (Seedling)	945.7	75.66	44.8	36.8	100
	CD 0.05	41.01	13.54	-	-	

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