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EVALUATION OF CITRUS ROOTSTOCK GERMPLASM COLLECTED FROM INDIGENOUS SOURCES FOR PRE-BEARING PERFORMANCE

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For pre-bearing performance *Citrus* rootstock germplasm, 13 strains of Rangpur lime (*Citrus limonia* Osbeck), 9 strains of rough lemon (*C. jambhiri* Lush.), 9 strains of trifoliate orange (*Poncirus trifoliata* (L) Raf.), 4 *Citrus* hybrid and three other rootstocks were compared. The strains of rough lemon, Rangpur lime and *Citrus volkameriana* Tan. Pasq. were observed to be vigorous for plant height, stem girth and canopy spread. *Citrus karna* Raf.. and Sunki mandarin (*C. reticulata* Blanco) were moderate in growth. The trifoliate orange and *Citrus* hybrids was comparatively better than trifoliate orange strains. Strainal variation for pre-bearing performance was observed in different rootstock groups. The strains of trifoliate orange viz. Trifesta and English Large were observed better in growth. These strains can be used in breeding programmes for transfer of *Phytophthora* and *Citrus* nematode resistance to the hybrids along with vigorous growth. Among Rangpur lime strains, Poona, Srirampur, Knorr and Australia were very vigorous in growth, whereas 8748 and 8784 were slow growing. Similarly, among rough lemon strains, 14-9-13 and Assam were vigorous and Jullandhari Khatti and Chethalli were slow in growth. Flowering was observed only in Rangpur lime (7247 and Poona Srirampur), rough lemon (14-9-13) and *Citrus volkameriana*.

Key words : *Citrus* rootstocks, rough lemon, Rangpur lime, trifoliate orange, germplasm, pre-bearing performance

Citrus is the third largest fruit crop in India with an estimated production of 29.79 lakh metric tones from an area of 3.70 lakh hectares (Chadha and Singh, 1996). The propagation of commercial *Citrus* plants by budding on to seedling rootstocks is the most common method in *Citrus* nurseries. Rootstocks exert profound influence on precocity, vigour, yield, quality, disease resistance and nutrient uptake of the scion budded on it (Agarwal, 1982). Rough lemon and Rangpur lime are the two major rootstocks used for *Citrus* propagation in India but both are susceptible to *Phytophthora* diseases and *Citrus* nematode (Fouque *et al.*, 1977). These rootstocks are vigorous in growth and produce good yield. On the other hand trifoliate oranges are not favoured due to their comparatively less vigorous growth, but are resistant to *Phytophthora* diseases and *Citrus* nematode (Bitters *et al.*, 1973 and Hearn *et al.*, 1974). Diversity within these three rootstocks is enormous (Chadha and Singh, 1996) and many variable types within each species have been reported with respect to disease resistance and plant vigour (Iyer *et al.*, 1983; Agarwal, 1986). Information on the vigour of these rootstocks is almost lacking. With this objective, a programme of germplasm collection and evaluation was initiated at National Research Centre for Citrus, Nagpur and the results of pre-bearing performance of 38 rootstocks have been reported here.

MATERIALS AND METHODS

In 1992, seeds of 38 rootstocks were collected from different indigenous sources (Table 1). The seeds were treated with Carbendazim before sowing in trays having a mixture of soil and sand (1:1). After six months, nucellar seedlings were transplanted to polyethylene bags (15" × 12") containing a mixture of soil and sand (1:1). One year old seedlings were planted in the field germplasm repository at a spacing of 6 m × 6m during the monsoon season (August) of 1993. All the plants were maintained on drip irrigation system and were given the recommended doses of macro and micro nutrients. The plants were sprayed with insecticides as and when required to check the incidence of insect pests. The soil type was Black cotton with a pH of 7.2, clay content 62.1 per cent, sand 9.7 per cent, silt 28.2 per cent, organic carbon < 2 per cent, Electrical conductivity 50 μ mhos/cm. The climate at Nagpur is sub tropical humid type and the maximum temperature goes upto 47°C during extreme summer and minimum to 8°C during extreme winter. The average rainfall is 1000 mm per annum. Every year, the plants were observed for vegetative characters viz. height, stem girth and east-west and north-south spread of the canopy and the initiation of flowering during January-February. The canopy volume was calculated using Castle's formula. $0.5236 \times h\ d^2$, where h = canopy height and d = canopy diameter (Castle, 1983). The mean values for different characters were compared by Duncan's Multiple Range test. The performance of different rootstocks has been observed after 4 years of planting.

RESULTS AND DISCUSSION

I. Performance of Rangpur lime strains

There were significant variations for the vegetative and reproductive performance among different Rangpur lime strains (Table 2). Maximum plant height (2.82 m) was recorded in Srirampur strain, followed by Knorr (2.77 m) and Kirumakki (2.70 m), but they were *at par* with Australia, 8784, Philippine Red Lime, 7247, Poona, Pooklingminz, Souranthan and U.S.A. Minimum height was in 8748 (1.25 m) followed by Poona Srirampur (1.61 m), but they were statistically similar to Australia, 8784, Pooklingminz and U.S.A. Highest stem girth was recorded in Kirumakki (30.50 cm), followed by Knorr, Srirampur and Philippine Red Lime (30.00, 29.50 and 29.00 cm, respectively), but the girth in these strains was not statistically different from Australia, 8784, 7247, Poona, Pooklingminz, Souranthan and U.S.A. Lowest stem girth was recorded in 8748 (14.37 cm), followed by Poona Srirampur (18.25 cm), but it was similar to that of Australia, 8784, Poona and U.S.A. Canopy volume was recorded maximum in Poona (5.79 m^3), followed by Srirampur (4.73 m^3), Knorr (4.70 m^3), Australia (4.49 m^3), 7247 (4.40 m^3), Kirumakki (4.27 m^3) and Souranthan (3.98 m^3), but they were statistically same to Philippine Red Lime, Pooklingminz and U.S.A. Minimum canopy volume was recorded in 8748 (0.50 m^3), followed by 8784 (1.83 m^3) and Poona Srirampur (1.93 m^3), but they were *at par* with Philippine Red Lime. Pooklingminz and U.S.A.. Rangpur lime, Poona, Srirampur, Knorr, Australia, 7247, Kirumakki and Souranthan were vigorously growing strains and 8748 and Poona Srirampur were slow growing, where as other strains exhibited intermediate growth. Flowering initiation was recorded only in 7247 and Poona Srirampur, indicating their precocious nature of bearing. Further Philippine Red lime, 8748 and Poona were observed susceptible to *Phytophthora.*

II. Performance of rough lemon strains and other rootstocks

Statistically significant variations in vegetative performance of different rough lemon strains and

Table 1. Parentage and source of collection of different rootstocks and strains

	Rootstocks	Parentage		Strain	Source
1.	Rangpur lime	*Citrus limonia* Osbeck	1.	Australia	Bangalore
			2.	Knorr	Bangalore
			3.	Kirumakki	Bangalore
			4.	8784	Bangalore
			5.	Srirampur	Tirupati
			6.	Philippine Red lime	Rahuri
			7.	7247	Chethalli
			8.	8748	Chethalli
			9.	Poona	Chethalli
			10.	Pooklingminz	Chethalli
			11.	Souranthan	Chethalli
			12.	U.S.A.	Chethalli
			13.	Poona Srirampur	Chethalli
2.	Rough lemon	*Citrus jambhiri* Lush	14.	14-9-13	Tirupati
			15.	Limonaria	Rahuri
			16.	Assam	Rahuri
			17.	South Africa	Rahuri
			18.	Jullandhari Khatti	Abohar
			19.	Chethalli	Rahuri
			20.	Sohsarkar	New Delhi
			21.	Mithi Tulia	New Delhi
			22.	Local	Nagpur
3.	Other rootstocks	*C. volkameriana* Tan.and Pasq. *C. karna* Raf. *C. Reticulata* Blanco	23.	Volkamer lemon	Bangalore
			24.	Karan Khatta	New Delhi
			25.	Sunki mandarin	Tirupati
4.	Trifoliate orange	*Poncirus trifoliata* (L). Raf.	26.	Yamaguchi	New Delhi
			27.	Rubidoux	Chethalli
			28.	Argentina	Chethalli
			29.	Williams	Chethalli
			30.	Florida	Chethalli
			31.	Srirampur	Chethalli
			32.	U.S.A.	Chethalli
			33.	English Large	Chethalli
			34.	Trifesta	Tirupati
5.	Trifoliate orange hybrids	*C. limonia* × *P. trifoliata*	35.	CRH-41	Bangalore
		C. sinensis × *P. trifoliata* (L.) Osbeck [L.] Raf.. *C. sinensis* × *P.trifoliata C. paradisi Macf.* × *P. trifoliata*	36.	Troyer citrange Australia	Chethalli
			37.	Carrizo citrange	Abhor
			38.	Citrumelo 4475	Tirupati

Table 2. Vegetative and reproductive performance of different strains of Rangpur lime rootstock

S. No.	Strain	Plant height (m)	Stem girth (cm)	Canopy spread (m^3)	Flowering (Yes/No)
I.	**Rangpur lime (R.L.):**				
1.	R.L. Australia	2.14abc*	21.50 abc	4.49 ab	No
2.	R.L. Knorr	2.77 a	30.00 a	4.70 ab	No
3.	R.L. Kirumakki	2.70a	30.50a	4.27 ab	No
4.	R.L. 8784	1.96 abc	21.75 abc	1.83 bc	No
5.	R.L. Srirampur	2.82 a	29.50 a	4.73 ab	No
6.	R.L. Philipine Red Lime	2.45 ab	29.00 a	2.96 abc	No
7.	R.L. 7247	2.26 an	25.75 ab	4.40 ab	Yes
8.	R.L. 8748	1.25 cm 14.37 c	0.50 c	No	
9.	R.L. Poona	2.30 ab	24.25 ab	5.79 a	No
10.	R.L. Pooklingminz	2.12 abc	25.00 ab	3.19 abc	No
11.	Souranthan	2.44 ab	27.25 ab	3.98 ab	No
12.	R.L. U.S.A.	2.02 abc	23.00 abc	3.57 abc	No
13.	R.L. Poona Srirampur	1.61 bc	18.25 bc	1.93 bc	Yes
II.	**Rough lemon :**				
14.	Rough lemon 14-9-13	3.01 abc*	32.75 bc	9.81 ab	Yes
15.	Rough lemon Limonaria	3.12 ab	34.75 bc	8.43 ab	No
16.	Rough lemon Assam	3.29 a	33.50 bc	5.59 def	No
17.	Rough lemon South Africa	3.00 abcd	33.00 bc	5.94 def	No
18.	Rough lemon Jullandhari Khatti	2.60 de	31.00 cd	3.78 ef	No
19.	Rough lemon Chethalli	2.81 bcd	32.75 bc	3.68 f	No
20.	Rough lemon Sohsarkar	3.02 abc,33.25 bc	6.56 cde	No	
21.	Rough lemon Mithi Tulia	2.86 bcd	30.00 cd	4.58 def	No
22.	Rough lemon Local	3.11 ab	36.75 b	7.12 bcd	No
	Other rootstocks				
23.	*Citrus volkameriana*	3.20 ab	41.87 a	10.94 a	No
24.	*Citrus Karna*	2.70 cd	32.00 bc	4.63 def	Yes
25.	Sunki mandarin	2.26 e	26.75 d	2.92 f	No
III.	**Trifoliate orange**				
26.	Trifoliate orange Yamaguchi	1.53 de*	10.32 de	0.25 cd	No
27.	Trifoliate orange Rubidoux	2.25 abc	12.32 de	0.23 d	No
28.	Trifoliate orange Argentina	1.69 cde	11.75 def	0.27 cd	No
29.	Trifoliate orange Williams	1.01 f	8.00 g	0.11 d	No
30.	Trifoliate orange Florida	1.05 f	8.25 fg	0.15 d	No
31.	Trifoliate orange Srirampur	1.02 f	9.32 efg	0.16 d	No
32.	Trifoliate orange U.S.A.	1.48 ef	11.32 defg	0.21 d	No
33.	Trifoliate orange English Large	2.04 bcde	13.25 cd	0.62 bc	No
34.	Trifesta trifoliate orange	2.61 ab	20.75 a	0.96 b	No
IV.	**Trifoliate orange hybrids**				
35.	CRH-41	2.80 a	22.25 a	1.52 a	Yes
36.	Troyer citrange Australia	2.49 ab	21.00 a	0.99 b	No
37.	Carrizo citrange	2.47 ab	20.0 ab	0.81 b	No
38.	Citrumelo 4475	2.12 bcd	16.75 bc	0.75 b	No

*Values denoted by same letters are not statistically different from each other

other rootstocks were observed (Table 2). Maximum plant height was recorded in rough lemon Assam (3.29 m), followed by *C. volkameriana* (3.20 m), rough Limonaria (3.12 m) and rough lemon Local (3.11 m), however, it was not statistically different from 14-9-13, South Africa and Sohsarkar rough lemon strains. Minimum plant height was recorded in Sunki mandarin (2.26 m), followed by Jullandhari Khatti (2.60m). Other rough lemon strains and *C. karna* were possessing intermediate plant height. Stem girth was recorded maximum in *C. volkameriana* (41.87 cm). The stem girth in Local rough lemon (36.75 cm) was *at par* with 14-9-13, Limonaria, Assam, South Africa, Chethalli, Sohsarkar and *C. karna.* Minimum girth was recorded in Sunki mandarin (26.75 cm), but it was not significantly different from Jullandhari Khatti. Canopy volume was maximum in *C. volktameriana* (10.94 m^3), followed by 14-9-13 (9.81 m^3) and Limonaria (8.43 m^3). Lowest canopy volume was recorded in Sunki mandarin (2.92 m^3) and Chethalli rough lemon (3.60 m^3), but it was not different significantly from Assam, South Africa, Jullandhari Khatti, Sohsarkar, Mithi Tulia and *C. karna. C. volkameriana* and rough lemon 14-9-13 and Assam were growing vigorously. The growth in Local and Sohsarkar strains was intermediate, whereas in Sunki mandarin, *C. karna* and remaining strains of rough lemon, the growth was very slow. Flowering initiation was recorded only in 14-9-13 rough lemon and *C. karna.* Rough lemon, Jullandhari khatti, *C. karna* and Sunki mandarin were susceptible to *Phytophthora* on the basis of field symptoms observed visually and Sunki mandarin was susceptible to leaf miner.

III. Performance of trifoliate orange strains and trifoliage orange hybrids

The plant vegetative characters were significantly different between different trifoliate orange strains and trifoliate orange hybrids (Table 2). Maximum plant height was recorded in CRH-41 (2.80 m), but it was *at par* with Trifesta, Troyer citrange Australia, Carrizo and Rudidoux, Minimum Plant height was observed in Williams (1.01m), Srirampur (1.02m). Florida (1.05m) and U.S.A. (1.48m), however Yamaguchi, Argentina and English Large were statistically similar in plant height to U.S.A. Maximum stem girth was recorded in CRH-41 (22.25 cm), followed by Troyer citrange Australia (21.00 cm), Trifesta trifoliate orange (20.75 cm), and Carrizo citrange (20.00 cm). However stem girth was not statistically different in Carrizo and citrumelo, citrumelo and English Large and English large, U.S.A., Arentina, Rubidoux and Yamaguchi. Minimum stem girth was recorded in Williams (8.00 cm), but it was *at par* with Florida, Srirampur and U.S.A., Maximum canopy volume was recorded in CRH- 41 (1.52 $m,^3$), followed by Troyer citrange Australia (0.99 m^3), Trifesta trifoliate orange (0.96 m^3), Carrizo citrange (0.81 m^3), citrumelo (0.75m^3) and English Large (0.62 m^3). Minimum canopy volume was recorded in Williams (0.11 m^3), Florida (0.15m^3), Srirampur (0.16m^3), U.S.A. (0.21m^3) and Rubidoux (0.23m^3), however they were *at par* with Yamaguchi and Argentina. Flowering was observed only in CRH-41. It was clear that trifoliate hybrids were more vigorous in growth as compared to trifoliate orange strains. CRH-41 was the most vigorous hybrid followed by Troyer, Carrizo and citrumelo, however, vigour was same to hybrids in trifesta trifoliate orange. Among trifoliate oranges, Trifesta and English Large were vigorously growing followed by Yamaguchi and Argentina. In other trifoliate orange strains growth was very slow. All the trifoliate orange strains and hybrids were susceptible to *Citrus* mites and CRH-41 was observed susceptible to *Phytophthora.*

It was evident from this study that strains of rough lemon and Rangpur lime, C. volkameriana and C. karna were vigorous in growth and trifoliate

orange strains and trifoliate orange hybrids were slow in growth. However, differences in vigour were observed within the strains of the same rootstock. The strainal variation for growth vigour in different strains of Rangpur lime, rough lemon and trifoliate orange was also observed earlier by other workers, but they have included different strains than those used in these studies (Prasad *et al.*, 1991 and Agarwal, 1986). Excessive vigour of the rough lemon and Rangpur lime rootstocks produced voluminous trees, but the fruit quality was poor. On the other hand, trifoliate oranges produced fruits of good quality of the scion, but were observed very slow in growth. The trifoliate hybrids grew better. In breeding programmes, vigorously growing trifoliate orange parents are required for the development of an intermediate type of the progeny as shown by citrus hybrids in this study. Among the vigorous rootstocks, rough lemon, Rangpur lime and *C. volkameriana* are found to be a good choice. But these are susceptible to *Phytophthora* diseases and *Citrus* nematode. On the other hand, trifoliate orange is slow growing, but it is resistant to *Phytophthora* diseases and *Citrus* nematode (Rao and Prasad, 1983). Parents like Trifesta and English Large trifoliate oranges should be tried as one of the parents in breeding programmes for getting vigorous and resistant rootstock. The significant differences in pre-bearing performance among different *Citrus* rootstocks and even within the strains of the same rootstock have been recorded.

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