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Behavior of various rootstock strains of Rough lemon and Rangpur lime on leaf nutrient composition and its effect on growth and yield of Nagpur mandarin

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ABSTRACT

An influence of 5 strains of Rough lemon (*C. jambhiri* Lush) and 11 strains of Rangpur lime (*C. limonia* Osbeck) rootstock on leaf nutrient composition and growth performance of Nagpur mandarin (*Citrus reticulata* Blanco) was studied during 1997-2001 under central Indian condition. Three years pooled average data on nutrient uptake during pre-bearing period showed significant variation as N (1.71 - 2.04 %), P (0.062 - 0.127 %), K (1.20 - 1.48%), Ca (2.50 - 3.07%), Fe (130.6 - 200.7 ppm), Mn (148.0 - 160.4 ppm) and Cu (8.5 - 10.3 ppm); while non-significant variation in Mg (0.43 - 0.60 %) and Zn (13.2 - 15.2 ppm). Nagpur mandarin plants grown on Rough lemon (Assam) rootstock showed weak nutrient accumulating behaviour and recorded lowest uptake of P, Ca, Fe, Zn, Mn and Cu which supported good vegetative growth and low fruit yield. While plants on Rangpur lime (Souranthan) recorded higher uptake of all the nutrients with higher vegetative growth and fruit yield. Plants grown on Rangpur lime (Shrirampur) recorded highest uptake of Fe and Mn, while N and Ca in Rangpur lime (7247). Similarly highest uptake of P, K, Zn and Cu was recorded in the plants grown on Rangpur lime (Souranthan), Rough lemon (Assam), Rough lemon (South Africa) and Rangpur lime (USA), respectively. Phosphorus uptake by different rootstocks showed positive and significant correlation with fruit yield, while uptake pattern of all other nutrients showed non-significant correlation with plant growth or fruit yield.

Key words: Fruit crops, citrus sp, Mandarin, Nutrient uptake, Central India, Black soils.

INTRODUCTION

Nagpur mandarin (*Citrus reticulata* Blanco), the most important citrus cultivar in India, is being grown commercially on Rough lemon (*C. jambhiri* Lush) and Rangpur lime (*C. limonia* Osbeck) rootstocks in central India. These rootstocks have several strains with variable characteristics. It is established that an amount of mineral element in the scion is greatly influenced by rootstock and scion could obtain nutrients in different degree on different rootstocks under different climatic conditions. Hence, nutrients has to be supplied as per the nutrient absorbing characteristics of the rootstock for certain agro-climatic conditions (Fallahi and Rodney, 3; Marathe *et al*., 4). According to Smith *et al*. (5), the differential capacity of the rootstock for certain microelements could be decisive in determining their adaptability in various soil types. Such a scientific information on different strains of Rangpur lime and Rough lemon for Nagpur mandarin is not available. An attempt has, therefore, been made to study the response of well known rootstock strains of Rough lemon and Rangpur lime on leaf mineral composition and growth performance with Nagpur mandarin as a scion.

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MATERIALS AND METHODS

The study was conducted during 1997-2001 on Nagpur mandarin trees, budded on 5 strains of Rough lemon and 11 strains of Rangpur lime planted at a distance of 6 m x 6 m, at National Research Centre for Citrus, Nagpur. The soil was black clayey, slightly alkaline having 30-45 cm depth, pH 8.01, EC 0.20 dS/m. The available nutrients in the soil were N 102 ppm, P 10.5 ppm, K 115 ppm, Zn 0.68 ppm, Mn 14.3 ppm, Fe 25.1 ppm and Cu 3.2 ppm. The climatic environment comprises tropical dry subhumid with hot and dry summer having mild winter, with average annual rainfall of 983.3 mm and mean annual temperature 26.4°C. The experimental layout consisted of 4 replications having 2-tree unit in randomised block design. The various rootstocks used were Assam, 14-9-13, Chethalli, South Africa, Jallundhari Khatti strains of Rough lemon and

Shrirampur, 7247, 8747, 8748, Texas, Poona, Poona Shrirampur, USA, Pookling Minj, Philippine Red lime and Souranthan strains of Rangpur lime.

The 5-7 months old leaves were collected from *Ambia* (February flush) shoots from each plant (Embleton and Jones, 2) and were washed thoRoughly in sequence with water, liquid soap, acidic water and glass redistilled water. The leaves were dried in open and then in oven at 70°C (± 5°C). Nitrogen was determined by micro-kjeldhal method and other nutrients were determined in di-acid (nitric-perchloric acid) wet digests. Phosphorus was determined by vanadomolybdate method, potassium by flame photometry and Ca^{++}, Mg^{++} by titrimetric estimation (Chapman and Pratt, 1). All the micronutrients (Zn, Fe, Cu and Mn) were determined using atomic absorption spectrophotometer. The data on nutrient uptake pattern were recorded consistently during pre-bearing years (1997–99) so as to get clear picture of nutrient uptake pattern which otherwise vary during fruiting years. The data was pooled together and analysed statistically for final interpretation besides their analysis on yearly basis. Vegetative growth was recorded during 1999, while yield data was recorded during bearing years (2000 and 2001) and discussed on pooled basis.

RESULTS AND DISCUSSION

A majority of rootstocks imparted a significant influence on the nutrient composition of Nagpur mandarin leaves. The difference between highest and lowest nutrient uptake values were high in K (105%), Fe (54%) and Mg (40%) while it was less than 24 % in rest of the nutrients. Similarly, marked annual variation were also observed (Table 1, 2) in micronutrients uptake by different rootstocks.

The nitrogen uptake in the leaves of Nagpur mandarin on various rootstocks differ significantly during all the years of experimentation. The nitrogen content was below the optimum values during 1997, which further decreased during subsequent years, might be due to increased vegetative growth of the plants during initial period. The pooled average data showed that highest nitrogen uptake was in Rangpur lime (7247) followed by Shrirampur and 7247 strains of Rangpur lime. While it was lowest in Philippine Red lime and Souranthan strains followed by Poona Shrirampur and USA strains of Rangpur lime. Phosphorus uptake on various rootstocks also showed significant variation during all the years. The pooled average data showed that the highest P uptake was in Souranthan followed by Philippine Red lime, Pookling Minj and 7247 strains of Rangpur lime. While it was consistently low in Rough lemon (Assam) followed by

Table 1. Effect of different rootstock strains of Rough lemon and Rangpur lime on macronutrient uptake pattern of Nagpur mandarin.

Rootstocks	Nitrogen (%)				Phosphorus (%)				Potassium (%)				Calcium (%)				Magnesium (%)			
	1997	1998	1999	PA	1997	1998	1999	PA	1997	1998	1999	PA	1997	1998	1999	PA	1997	1998	1999	PA
Rough lemon (Assam)	1.75	2.12	1.87	1.91	0.038	0.040	0.110	0.062	1.57	1.31	1.56	1.48	3.52	1.50	2.54	2.52	0.35	0.52	0.64	0.50
Rough lemon (14-9-13)	2.03	1.91	1.85	1.93	0.040	0.043	0.123	0.069	1.54	0.87	1.52	1.31	3.57	1.85	2.80	2.74	0.54	0.55	0.37	0.49
Rough lemon (Chethalli)	2.00	1.83	1.70	1.84	0.070	0.042	0.177	0.096	1.48	1.13	1.47	1.36	3.35	1.60	2.54	2.50	0.59	0.66	0.56	0.60
Rough lemon (South Africa)	1.98	1.77	1.72	1.82	0.065	0.045	0.184	0.098	1.45	1.17	1.34	1.32	3.13	1.95	2.67	2.58	0.58	0.55	0.44	0.52
Rough lemon (Jallundhari Khatti)	2.19	1.70	1.83	1.90	0.103	0.037	0.170	0.103	1.58	1.02	1.29	1.29	2.96	2.15	2.99	2.70	0.53	0.58	0.36	0.49
Rangpur lime (Shrirampur)	2.32	1.79	1.89	2.00	0.085	0.037	0.178	0.100	1.71	1.14	1.18	1.34	3.05	1.70	2.93	2.56	0.48	0.55	0.48	0.50
Rangpur lime (7247)	2.37	1.70	2.05	2.04	0.095	0.058	0.176	0.109	1.50	1.38	1.50	1.46	3.26	2.60	3.15	3.00	0.36	0.58	0.40	0.45
Rangpur lime (8747)	2.14	1.61	2.17	1.97	0.105	0.040	0.166	0.104	1.54	1.06	1.38	1.32	3.22	2.47	3.12	2.94	0.43	0.56	0.52	0.50
Rangpur lime (8748)	2.15	1.61	1.99	1.91	0.078	0.047	0.147	0.091	1.30	1.13	1.18	1.21	3.14	2.15	3.19	2.82	0.29	0.52	0.48	0.43
Rangpur lime (Texas)	2.00	1.65	2.00	1.88	0.058	0.045	0.168	0.090	1.48	1.23	1.46	1.39	3.31	2.25	3.64	3.07	0.27	0.61	0.56	0.48
Rangpur lime Poona)	1.98	1.70	1.82	1.83	0.070	0.057	0.175	0.101	1.30	1.19	1.30	1.26	3.52	1.60	3.12	2.75	0.38	0.46	0.56	0.46
Rangpur lime (Poona Shrirampur)	2.12	1.53	1.60	1.75	0.068	0.044	0.158	0.090	1.47	1.08	1.05	1.20	3.48	2.15	3.06	2.89	0.32	0.58	0.72	0.54
Rangpur lime (USA)	2.14	1.61	1.62	1.79	0.053	0.053	0.183	0.096	1.52	1.31	1.31	1.38	3.13	1.75	3.25	2.71	0.51	0.55	0.56	0.54
Rangpur lime (Pookling Minj)	2.23	1.76	1.74	1.91	0.085	0.084	0.178	0.116	1.38	1.20	1.33	1.30	3.35	2.15	2.99	2.83	0.61	0.43	0.48	0.51
Rangpur lime (Philippine Red lime)	1.83	1.58	1.72	1.71	0.073	0.105	0.189	0.122	1.45	1.08	1.40	1.31	3.48	1.80	3.32	2.87	0.53	0.49	0.52	0.51
Rangpur lime (Souranthan)	1.76	1.55	1.83	1.71	0.083	0.103	0.195	0.127	1.38	1.23	1.39	1.33	3.57	1.90	3.32	2.93	0.56	0.46	0.44	0.49
CD (P=0.05)	0.27	0.24	0.22	0.16	0.029	0.022	0.026	0.015	NS	0.24	0.26	0.20	NS	NS	0.60	0.36	0.22	NS	NS	NS

PA-Pooled averages, NS-Non significant

Rough lemon (South Africa) and Rangpur lime (Texas). The potassium uptake during all the years was well within the optimum limit in all the rootstocks. The pooled average data showed that the potassium uptake differed significantly among the various rootstocks. The highest uptake was observed in Rough lemon (Assam) which was at par with 7247, Texas and USA strains of Rangpur lime, while it was lowest in Poona Shrirampur, 8748 and Poona strains of Rangpur lime.

A rootstock is an avid accumulator of Ca would impart consequent effect on scion which in turn would ensure not only fruits with better total soluble solids but also prolong the orchard life as well. The calcium content in the leaves of Nagpur mandarin on various rootstocks did not differ significantly during 1997 and 1998. However, the pooled average data showed significant differences with the highest uptake in 7247 followed by Texas and 8747 strains of Rangpur lime, while it was lowest in Assam strain followed by Chethalli and South Africa strains of Rough lemon. The magnesium uptake among the different rootstocks varied significantly only during 1997. The pooled average data also showed non-significant variation but the highest uptake was observed in Rough lemon (Chethalli) followed by Poona Shrirampur and USA strains of Rangpur lime, while it was lowest in Rangpur lime (8748).

A majority of citrus orchards in India are deficient in zinc and any rootstock found suitable in Zn-deficient soils would be handy for successful citrus cultivation. Zinc uptake by different rootstocks was below the optimum limit during all the years and varied significantly only during 1999. The pooled average data showed that the highest uptake was observed in Rough lemon (South Africa) followed by Rangpur lime (Philippine Red lime) and Rough lemon (Jallundhari Khatti), while it was lowest in Rough lemon (Assam) and Rangpur lime (Pookling Minj). Taylor and Dimsey (6) reported more accumulation of zinc in citrus trees budded on Rough lemon rootstocks. The iron content in leaves of Nagpur mandarin on different rootstocks was well above the optimum limit and varied significantly during most of the years except 1999. The pooled average data showed highest Fe uptake in Shrirampur strain followed by Texas, 7247 and 8747 strains of Rangpur lime, while lowest in Rough lemon (Assam), Rangpur lime (Pookling Ming) and Rough lemon (Chethalli) rootstock. The copper content in leaves of Nagpur mandarin on different rootstocks varied significantly during all the years. Rangpur lime (USA) recorded highest uptake followed by Poona and

Table 2. Effect of different rootstock strains of Rough lemon and rangpur lime on micronutrient uptake pattern of Nagpur mandarin.

Rootstocks	Iron (ppm)				Zinc (ppm)				Manganese (ppm)				Copper (ppm)			
	1997	1998	1999	PA	1997	1998	1999	PA	1997	1998	1999	PA	1997	1998	1999	PA
Rough lemon (Assam)	103.7	100.4	187.7	130.6	14.5	14.5	10.7	13.2	151.9	156.5	140.2	149.5	10.1	8.5	7.1	8.5
Rough lemon (14-9-13)	162.0	134.6	173.0	156.5	17.1	13.2	11.8	14.0	162.9	142.0	147.5	150.8	10.9	9.0	7.9	9.2
Rough lemon (Chethalli)	109.7	153.2	178.3	147.1	15.6	14.8	12.4	14.3	158.2	149.7	144.3	150.7	9.1	8.4	8.8	8.8
Rough lemon (South Africa)	122.0	129.8	248.0	166.6	17.7	12.8	15.3	15.2	160.9	139.5	150.7	150.4	11.1	7.7	9.2	9.3
Rough lemon (Jallundhari Khatti)	229.0	119.0	200.9	183.0	18.3	12.7	12.4	14.5	182.9	146.9	144.5	158.1	10.6	9.0	9.1	9.6
Rangpur lime (Shrirampur)	288.1	129.2	184.8	200.7	16.8	13.0	12.0	13.9	176.3	156.9	148.1	160.4	10.1	9.3	9.4	9.6
Rangpur lime (7247)	266.6	133.3	180.2	193.3	15.1	14.4	13.7	14.4	181.5	149.6	145.1	158.7	9.9	8.5	9.7	9.3
Rangpur lime (8747)	266.9	108.0	195.1	190.0	17.6	12.0	13.2	14.2	188.4	144.6	142.3	158.4	9.9	8.0	9.3	9.1
Rangpur lime (8748)	201.6	104.7	158.8	155.0	16.9	12.3	11.8	13.7	160.6	150.1	140.7	150.5	8.9	8.0	9.1	8.7
Rangpur lime (Texas)	139.5	175.9	277.0	197.5	15.7	14.6	12.9	14.4	174.7	154.0	147.2	158.6	10.1	8.3	9.4	9.3
Rangpur lime(Poona)	150.1	132.9	169.0	150.6	16.6	12.4	11.9	13.6	172.6	158.8	145.9	159.1	12.4	8.2	10.1	10.2
Rangpur lime (PoonaShrirampur)	133.5	186.7	210.4	176.8	17.3	11.8	11.6	13.6	161.1	159.5	140.5	153.7	11.1	8.8	9.5	9.8
Rangpur lime (USA)	131.0	128.9	195.6	151.8	15.6	12.6	15.1	14.4	153.6	145.7	144.6	148.0	10.3	9.3	11.3	10.3
Rangpur lime (Pookling Ming)	134.7	117.0	163.0	138.3	15.9	12.8	11.4	13.4	151.1	158.3	137.4	149.0	10.8	8.0	9.1	9.3
Rangpur lime (Philippine Red lime)	133.5	113.8	204.9	150.7	15.4	12.9	15.6	14.6	160.4	160.1	149.7	156.7	11.2	9.0	10.1	10.1
Rangpur lime (Souranthan)	136.3	129.3	199.7	155.1	15.8	13.3	13.5	14.2	150.9	165.6	143.2	153.2	10.5	8.6	10.1	9.7
CD (P=0.05)	53.3	34.0	NS	29.2	NS	NS	2.64	NS	14.0	NS	7.58	7.1	1.31	1.19	1.39	0.87

PA-Pooled averages, NS-Non significant

Philippine Red lime strains of Rangpur lime, while it was lowest in Rough lemon (Assam), Rangpur lime (8748) and Rough lemon (Chethalli). The manganese content in leaves of Nagpur mandarin on different rootstocks varied significantly during most of the years except 1998. Shrirampur and Poona strains of Rangpur lime recorded highest Mn uptake, while it was lowest in Rough lemon (Assam) followed by Pookling Minj and USA strains of Rangpur lime.

The vegetative growth of the plant as indicated by canopy volume varied from 8.0 to 14.95 m^3 among the various rootstocks (Table 3). Rangpur lime (8747) recorded highest vegetative growth of Nagpur mandarin plants followed by Shrirampur (13.16 m^3) and Souranthan (11.94 m^3) strains of Rangpur lime. The relative ranking of elements in different rootstocks showed that plants on these rootstocks showed comparatively higher nutrient accumulating behavior of all nutrients except Ca uptake in Shrirampur and N and Mn uptake in Souranthan strains of Rangpur lime. The lowest vegetative growth (8.0 m^3) was observed on Poona Shrirampur strain of Rangpur lime which showed weak nutrient accumulating behaviour of most of the nutrients except Ca, Mg and Cu. While plants budded on Rough lemon (Jallundhari Khatti) also exerts lower vegetative growth (8.16 m^3), though it shows higher accumulation of most of the nutrients except Ca and K.

The correlation study showed that nutrient uptake of most of the nutrients except Ca and Cu, had a positive correlation with growth of the plant. But the results were non-significant. This indicates that the nutrient uptake was not related to the growth habit of the plant but was as per the inherent nutrient absorbing characteristics of that particular rootstock.

The two years pooled average data showed that the yield non-significantly varied from 63.6 to 135.3 fruits/plant/year. Plants budded on Rangpur lime (8748) recorded highest fruit yield with weak nutrient accumulating behaviour (Table 3). It was followed by Philippine Red lime (134.3 fruits/plant), Souranthan (133.3 fruits/plant) and Shrirampur (132.9 fruits/plant) strains of Rangpur lime which had comparatively higher nutrient uptake except N and Fe in Philippine Red lime, N in Souranthan and Ca in Shrirampur strains of Rangpur lime. Rough lemon (Assam) recorded lowest fruit yield followed by Poona Shrirampur (96.4 fruits/plant) and 7247 (102.3 fruits/plant) strains of Rangpur lime. The correlation study showed that among macronutrients, uptake pattern of P showed positive significant

Table 3. Relative ranking of scion nutrient levels and its correlation with growth and yield of Nagpur mandarin

Rootstocks	Relative ranking									Canopy Volume(m^3)	Yield (pooled mean) Fruits/tree/ year
	N	P	K	Ca	Mg	Zn	Mn	Fe	Cu		
Rough lemon (Assam)	5	14	1	16	5	12	16	16	12	8 (10.28)	16 (63.8)
Rough lemon (14-9-13)	4	13	9	10	6	7	10	7	8	5 (11.11)	7 (120.4)
Rough lemon (Chethalli)	8	10	5	15	1	5	11	13	10	4 (11.3)	11 (111.3)
Rough lemon (South Africa)	10	9	8	13	3	1	13	6	7	13 (9.1)	9 (118.6)
Rough lemon (Jallundhari Khatti)	6	6	11	12	6	3	6	5	6	15 (8.16)	10 (114.1)
Rangpur lime (Shrirampur)	2	8	6	14	5	8	1	1	6	2 (13.16)	4 (132.9)
Rangpur lime (7247)	1	4	2	1	9	4	3	3	7	7 (10.6)	14 (102.3)
Rangpur lime (8747)	3	5	8	3	5	6	4	4	9	1 (14.95)	5 (126.4)
Rangpur lime (8748)	5	11	13	8	10	9	12	9	11	11 (9.34)	1 (135.3)
Rangpur lime (Texas)	7	12	3	2	7	4	5	2	7	12 (9.17)	12 (108.8)
Rangpur lime (Poona)	9	7	12	9	8	10	2	12	2	9 (10.25)	13 (103.3)
Rangpur lime (Poona Shrirampur)	12	12	14	5	2	10	8	14	4	16 (8.0)	15 (96.4)
Rangpur lime (USA)	11	10	4	11	2	4	14	10	1	10 (9.97)	6 (122.4)
Rangpur lime (Pookling Ming)	5	3	10	7	4	11	15	15	7	14 (8.98)	8 (119.1)
Rangpur lime (Philippine Red Lime)	13	2	9	6	4	2	7	11	3	6 (10.97)	2 (134.3)
Rangpur lime (Souranthan)	13	1	7	4	6	6	9	8	5	3 (11.94)	3 (133.3)
Correlation with canopy volume ('r' value)	0.274NS	0.162NS	0.253NS	-0.023NS	0.042NS	0.332NS	0.063NS	0.294NS	-0.102NS		
Correlation with fruit yield ('r' value)	-0.139NS	0.584Sig.	-0.440NS	0.207NS	-0.077NS	0.299NS	0.403NS	-0.348NS	0.268NS		

Figures in parenthesis showed actual values, NS-non significant, Sig-significant

correlation (r = 0.584) with fruit yield, while N, P and Mg showed negative and non-significant correlation. Similarly all the micronutrients also showed non-significant correlation with fruit yield. However, comparatively higher positive correlation was observed with Zn (r = 0.403) uptake followed by Fe and Cu while Mn showed negative correlation.

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