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Leaf nutrient composition, its correlation with yield and quality of sweet orange and soil microbial population as influenced by INM in Vertisol of central India

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ABSTRACT

A field trial was conducted on eight-year-old sweet orange orchards grown on black soils for three years under central Indian conditions. Different treatments involved application of FYM, vermi-compost, wheat straw on nitrogen equivalent basis and green manuring with sun hemp as singly or in combination with inorganic or bio-fertilizers like *Azotobacter* and PSB including control plots. The results showed highest concentration of N (2.19%), P (0.111%), K (1.38%), Mg (0.302%), Zn (26.3 ppm) and Cu (16.2 ppm) in the leaves with the combined application of FYM along with 50% dose of inorganic fertilizers and Ca (2.51%) with green manuring with sun hemp along with 50% dose of inorganic fertilizers. Sole application of FYM (to supply 100% N) recorded highest Mn (75 ppm) and Fe (155 ppm) contents followed by combined application of FYM (to supply 75% N) along with *Azotobacter* and PSB. Significant positive correlation was observed between leaf macronutrients content and fruit yield while leaf Zn content with both yield and quality of fruits. Soil bacterization with *Azotobacter* and PSB increased their abundance, multiplied well and were able to save 25 per cent dose of organic manures or fertilizers applied for N and P nutrition. Organic manures were highly effective in increasing the microbial population in the soil.

Key words: Sweet orange, leaf nutrient composition, integrated nutrient management, yield, quality.

INTRODUCTION

Nutrient responsive nature of citrus is well proven since the commercial cultivation of citrus come into being. There are numerous literature emanated in India about the wide range of nutrient deficiencies in citrus orchards (Sekhon *et al.*, 12; Malewar, 8; Kohli *et al.*, 7) and balanced nutrition programme is mandatory to maintain a sustained productive life of orchard in addition to quality production (Ghosh, 4). Use of organic manures along with fertilizers or inclusion of green manure is a proven technology to build up fertility status of soil. However, it always, does not give true picture of nutrient status of plants. In fruit crop like citrus, leaves have been found to be practically sensitive and convenient index of the nutrient status of the plant and leaf nutrient composition is considered to be a basic tool for the investigation of soil fertility problems. Lot of research is being done on use of integrated supply of nutrients based on soil fertility status but information on leaf nutrient uptake and its correlation with yield and quality parameters is lacking. Hence, the present investigation was carried out to find out most efficient manuring system and its possible effects on nutrient composition, yield and quality of sweet orange along with soil microbial population.

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MATERIALS AND METHODS

An experiment was conducted at Regional Fruit Research Station, Katol, Maharashtra on eight-year-old sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi orchard grown on Vertisol. A total of 13 treatments replicated three times were executed in randomized block design having two plants per unit. The treatments consisted of 13 combinations, *viz*., T_1 = Recommended Dose of Fertilizers (RDF) (1000 g N + 400 g P_2O_5 + 400 g K_2O/tree/year), T_2 - FYM (to supply 100% N), T_3 - vermicompost (to supply 100% N), T_4 - FYM (to supply 50% N) + 50% RDF, T_5 - vermicompost (to supply 50% N) + 50% RDF, T_6 - green manuring with sunhemp (*Crotolaria juncea*) (to supply 50% N) + 50% RDF, T_7 - wheat straw (to supply 50% N) + 50% RDF, T_8 - FYM (to supply 25% N) + 50% RDF + *Azotobacter* + phosphate solubilizing bacteria (PSB), T_9 - vermicompost (to supply 25% N) + 50% RDF + *Azotobacter* + PSB, T_{10} - 75% RDF + *Azotobacter* + PSB, T_{11} - FYM (to supply 75% N) + *Azotobacter* + PSB, T_{12} - vermicompost (to supply 75% N) + *Azotobacter* + PSB and T_{13} - control. The doses of organic manures were applied on nitrogen equivalent basis. Some important characteristics of the soil were as follows: pH 7.84, EC 0.30 dS/m, organic carbon 0.70%, CEC 46.5 cmol (p^+)/kg, available N, P_2O_5 and K_2O were 199.2, 19.1 and 50.8 kg/ha respectively, and all the micro-nutrients were above optimum range.

Leaf samples were collected after every six months to monitor changes in leaf macro- and micro-nutrients content and discussed on pooled average basis. Collected leaves were thoroughly washed and ground to have homogenous sample. Nitrogen was estimated through microKjeldhal steam distillation method. The samples were digested in tri-acid mixture (Chapman and Pratt, 2) and analysed for P using vanadomolybdo-phosphoric acid method, K flame photometrically and secondary (Ca and Mg) and micro-nutrients (Fe, Cu, Zn and Mn) using atomic absorption spectrophotometer. The composite soil sample during second year of study was used for estimation of microbial population following serial dilution method using specific media for each microbe (Sharma, 14).

For correlation studies with fruit yield and quality parameters such as percent juice recovery and TSS:acid ratio, different sets of leaf nutrients as major- and micro-nutrients were considered as independent variables. Treatment and replication wise data of two years was used to eliminate the treatment effects. The correlation studies also revealed the strength of inter-relationship between the casual variables. But only correlation coefficient values ('r' values) of resultant variables are presented.

RESULTS AND DISCUSSION

Highest concentration of N, P and K in the leaves of sweet orange was observed with the combined application of FYM to meet 50% N along with 50% dose of inorganic fertilizers. Application of vermicompost, 100% RDF as a sole and green manuring with sunhemp along with 50% dose of inorganic fertilizers were also equally effective in increasing N content in the leaves (Table 1). This might be due to added supply of nutrients, improved physical properties of soil and well developed root system resulting in to better absorption of water and nutrients. Ghosh and Besra (5) reported significantly higher content of major nutrients in the sweet orange leaves under the combined application of organic manures and inorganic fertilizers than those at the same level with inorganic fertilizers.

The observations (Table 1) also revealed that the treatments where only 75% dose of nutrients was applied through FYM (T_{11}) and vermicompost (T_{12}) along with *Azotobacter* and phosphobacteria (PSB) recorded slightly lower N and significantly higher P content than those corresponding treatments where 100% dose of nutrients was applied through FYM (T_2) and vermicompost (T_3). These observations clearly indicated that *Azotobacter* and PSB play key role in N_2 fixation and P solubilization, respectively, and can compensate or save 25% dose of organic manures or inorganic fertilizers supplied for N and P nutrition. The significant role of bio-fertilizers in enhancing the nutrient supply and uptake by fruit crops was also reported by Bhattacharyya (1) who showed that phosphate solubilizers in citrus growing soils of India have potential to solubilize insoluble phosphate equivalent to 30-50 kg P_2O_5 per ha through superphosphate.

Table 1. Leaf nutrient composition as affected by different INM treatments (pooled mean of four seasons).

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Zinc (ppm)	Manganese (ppm)	Iron (ppm)	Copper (ppm)
T_1	2.07	0.096	1.15	2.25	0.275	20.9	67.5	121.5	14.3
T_2	1.99	0.094	1.27	2.25	0.287	23.1	74.8	154.6	14.2
T_3	2.05	0.092	1.18	2.19	0.277	22.6	71.3	144.4	14.4
T_4	2.19	0.111	1.38	2.43	0.302	26.3	70.7	145.5	16.2
T_5	2.11	0.097	1.19	2.39	0.289	24.0	68.9	134.2	14.3
T_6	2.05	0.096	1.34	2.51	0.294	23.2	68.4	137.8	15.8
T_7	2.02	0.093	1.14	2.21	0.273	23.5	69.5	131.2	13.1
T_8	2.05	0.096	1.19	2.29	0.279	22.8	69.2	132.4	15.1
T_9	1.98	0.098	1.20	2.22	0.281	21.6	69.6	131.0	13.7
T_{10}	1.94	0.094	1.10	2.14	0.258	20.3	66.4	117.4	13.5
T_{11}	1.98	0.101	1.20	2.15	0.289	22.5	71.6	145.0	13.9
T_{12}	1.98	0.100	1.11	2.03	0.272	21.2	68.8	132.8	14.5
T_{13}	1.83	0.089	0.99	1.90	0.251	18.0	63.7	108.0	12.5
CD at 5%	0.13	0.005	0.09	0.15	0.013	1.52	4.49	10.4	1.96

The leaf Ca content was highest with green manuring with sun hemp along with 50% dose of inorganic fertilizers, while combined application of FYM (to supply 50% N) along with 50% dose of inorganic fertilizers recorded the highest Mg content. Hume *et al.* (6) reported positive correlation between levels of exchangeable Ca and Mg and their levels in the leaves of sweet orange. The micro-nutrients, *viz*., Fe, Mn and Zn content in the leaves showed significant variation due to different treatments. While Cu content varied to a great extent (9.7 to 20.0 ppm) and the results were non-significant during all the seasons. This might be due to the sprays of copper fungicides as a part of prophylactic measures to control fungal diseases. The highest content of Zn and Cu was recorded with the combined application of FYM (to supply 50% N) along with 50% dose of inorganic fertilizers. Malewar and Patil (9) reported improved Zn uptake by sweet orange with the application of 10 to 15 g organic manures per kg of soil. Substantial increase in Mn and Fe content was recorded with the sole application of FYM or in combination with bio-fertilizers *Azotobacter* and PSB. Findings on similar line were also reported by Seshadri and Madhavi (13).

The correlation coefficient values (Table 2) indicated that fruit yield was significantly correlated with all the major leaf nutrients. Highest significant positive correlation was observed with Ca (r = 0.538), Mg (r = 0.517), K (r = 0.468), N (r = 0.459) and P (r = 0.418) contents in the leaves in the decreasing order. These findings are in agreement with the results obtained by Dhillon and Dhatt (3) in Kinnow mandarin. The highest degree of correlation was observed in case of per cent fruit juice content with K (r = 0.556) followed by Mg (r = 0.537), Ca (r = 0.503) and N (r = 0.358) content in the leaves. However, the TSS : acid ratio showed strong positive correlation only with leaf Mg (r = 0.341) and K (r = 0.236) contents. Similar observations were made by Srivastava and Singh (15) in Nagpur mandarin reported positive correlation of fruit juice TSS with leaf K and N concentration.

Zinc concentration in leaf was observed to influence both fruit yield (r = 0.543) and quality parameters such as juice content (r = 0.517) and TSS : acid ratio (r = 0.364), depicting the significance of Zn in maintaining the quality production. Deficiency of zinc is globally considered as the most crunch nutritional problem in citrus growing belts for sustainable citrus production (Srivastava and Singh, 16). The Fe content in the leaf (Table 2) showed higher correlation with quality parameters as TSS : acid ratio (r = 0.562) and juice content (r = 0.271) compared to fruit yield (r = 0.215). The Cu content in the leaf showed positive correlation with fruit yield (r = 0.414) and juice content (r = 0.372), while no correlation was observed with TSS : acid ratio. The leaf Mn content showed no correlation with either fruit yield or any of the fruit quality parameters.

Considerable variation in population of various micro-organisms was observed due to different treatments of integrated nutrient management (Table 3). Treatments involving application of organic manures were highly effective in increasing microbial population compared to inorganic fertilizers and control. Highest bacterial population was recorded with the sole application of FYM (to supply 100% N)

Table 2. Correlation of leaf macronutrients content with yield and quality of sweet orange.

Leaf nutrient	Coefficient of correlation (r) values		
	Yield	Quality parameter	
		Percent juice recovery	TSS : acid ratio
Macro-nutrient			
N	0.459**	0.358**	0.109
P	0.418**	0.126	-0.063
K	0.468**	0.556**	0.236*
Ca	0.538**	0.503**	0.066
Mg	0.517**	0.537**	0.341**
Micro-nutrient			
Zn	0.543**	0.517**	0.364**
Fe	0.215	0.271*	0.562**
Mn	0.053	0.185	0.195
Cu	0.494**	0.372**	-0.170

*Significant at 5 and 1% levels

Table 3. Microbial population as affected by different INM treatments.

Treatment	Bacteria (x 10^6)	Fungi (x 10^5)	Actinomycetes (x 10^4)	Azotobacter (x 10^2)	PSB (x 10^4)
T_1	8	12	15	9	5
T_2	59	24	26	20	16
T_3	40	18	22	18	10
T_4	41	19	34	18	12
T_5	30	15	28	16	8
T_6	48	20	30	22	10
T_7	46	26	17	15	15
T_8	32	18	21	22	12
T_9	25	13	20	18	8
T_{10}	8	12	15	11	28
T_{11}	44	20	22	30	21
T_{12}	40	18	22	25	3
T_{13}	6	4	10	5	

followed by green manuring with sun hemp + 50% RDF. Green manure acts as an excellent substrate for soil microbes in increasing their population. While higher amount of decayed material available from wheat straw helps the fungal colonies to multiply and record highest fungal counts. Actinomycetes population was highest with the combined application of FYM along with 50% dose of inorganic fertilizers. Bacterization with *Azotobacter* and PSB increased their abundance and multiply well in sweet orange soils and their efficiency to multiply was comparatively higher in presence of organic manures, due to greater availability of organic carbon and mineralized nutrients for their proliferation and further cellular development. Highest population of *Azotobacter* and PSB was observed with the application of FYM (to supply 75% N) + *Azotobacter* + PSB. Increased population of soil microbes like bacteria (Tiwari *et al.*, 17), fungus (Naranjane *et al.*, 10) and actinomycetes (Patil and Varade, 11) was also observed with the application of organic manures, green manures as a sole or in combination with the inorganic fertilizers.

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