The Effect of Different Nutrient Management Practices on yield and leaf nutrient composition of Sweet Orange (*Citrus Sinensis* L.*Osbec*)

Abstract

The present study was carried out during three successive seasons. The experiment was laid out in Randomized block design (RBD) with thirteen treatments replicated four times to study the effect of different nutrient management practices on fruit yield and leaf nutrient composition. The result revealed that among the different treatments combination treatment (T_{13}) with Application of NPK in 8 splits with drip irrigation + vermicompost @ 3 tonne ha^{-1} and biofertilizers i.e *Azotobacter* and PSB @ 2000 ml per ha and trichoderma @ 1 kg ha^{-1} + 8 spraying of Zn (0.5%) , Fe (0.5%) and B (0.2%) found to be most effective in producing better yield and yield attributes. However, soil fertility as evident by changes in soil available N, P, K , S, Fe and Zn as well as leaf concentration of N, P, K , S, Fe, Zn and B significantly improved with combining application RDF, vermicompost and biofertilizer with or without fertigation along with foliar feeding of micronutrients viz. Zn, Fe and B.

Key Words – sweet orange, nitrogen, yield, zinc, iron and boron.

Introduction

The salubrious effect of adding mineral elements to soil to enhance plant growth have been know in agriculture for more than 2000 years. Nevertheless, even 158 years ago it was still a matter of scientific controversy as to whether mineral elements function as nutrients for plant growth. In addition to oxygen, hydrogen, carbon dioxide and water plant required at least 14 mineral elements for adequate nutrition (Mengal *et al.* 2001). Deficiency in any one of these mineral elements reduces plant growth and crop yields. The nutrients availability and uptake is influenced by soil physical, chemical, mineralogical and biological properties. The important soil properties that affect the nutrient availability include soil depth, soil pH, EC, $CaCO_3$ content, organic carbon content and plant nutrients concentration in soil solution. Sometimes soil possesses adequate amount of nutrient concentration in soil media but its availability become to plant is hindered due to some external factors, under such situation foliar nourishing of nutrient become necessary to save the crop, yield and quality of produce. Therefore coupling the soil application of fertilizers with foliar feedings of nutrients result in to in time correction of the nutrient deficiency and finally result in to enhanced crop growth, yield and improvement in quality.

Citrus (Citrus sinensis L.) is one of the important fruit crop of the world, occupied third position among the sub-tropical fruits (Gregory, 1993). In fact, soil is a focal point to spell out the supernova or debacle of citrus plantation next to climate. According to Randhawa (1970), soil site selection, soil pH, salt status, soil structure, abundance of free lime, presence of hard pan, drainage regime and soil depth are prime importance in citrus cultivation. For growing healthy and strong plant nutrient demanded is furnished by pairing of organic and inorganic nutrient sources. The average productivity of 'Mosambi' i.e. sweet orange is 14.9 t/ha which comparatively lower. One of the fundamental causes for low sweet orange orchard productivity in the soils of Marathwada region is due to various nutrient deficiencies. The conventional nutrient management strategy based mainly on macronutrient application in citrus orchards has not been very successful in expanding the productivity level (Srivastava *et al*., 2006). Therefore, it becomes necessary to integrate the nutrient sources and apply to the crop, so as to get benefit of both organics and inorganics. Organics mainly improve the soil condition and inorganics supply the nutrients in time. Soil reaction may be a problem in micronutrient deficiencies, necessitating application of foliar micronutrient sprays. Bio fertilizers are another alternative to replenish the loss of nutrient supplement system. These include N-fixures (Rhiozobium, Azotobacter, blue-green algae and Azolla), P-solubilizing bacteria and P-mobilizing fungi (VAM). Azotobacter, the heterotrophic free living nitrogen fixing bacteria is present in neutral and alkaline soils. To stabilize fruit production and quality, it is significant to provide the right amount of water and fertilizers at different growth stages not only enhances the growth of citrus trees, but also ameliorates yield and fruit quality (Shirgure *et al.*, 2001a). The nutritional management programme of inorganic fertilizer and organic fertilizer with soil application, fertigation and foliar application is going to helps to sustain the crop productivity of sweet orange in the region. It may also help to check the emerging deficiency of macronutrients and micronutrients.

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2. Material Method

Site Selection

The field experiments were conducted at Water Management Research Center, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in the year 2014-15 and 2015-16. Ten years old, fifty-two sweet orange trees having uniform growth and vigor were selected for experiment. Experimental site was fairly uniform and leveled. In third year experiment was conducted (2016-17), at Sweet Orange Research Center Badnapur, Dist. Jalna on eight years old orange orchard. Experimental site was fairly uniform with gentle slope.

Soil and their mineralogy

The soil of field experiments on Water management farm, VNMKV, Parbhani and SORC, Badnapur are medium deep, characterized by black colour dominated by montmorillonite clay with high coefficient of expansion and shrinkage leads to deep cracking. The soils are formed from basaltic material. According to 7th approximation, the soils are classified as Typic Haplusterts .

Experiment Details

The experiment was designed in Randomized Block Design comprising thirteen (13) treatments and four replications in sweet orange orchard.

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Treatment Details

T_1	RDF+ 4 spraying of (Zn+B+Fe)
T_2	RDF+ 6 spraying of (Zn+B+Fe)
T_3	RDF+ 8 spraying of (Zn+B+Fe)
T_4	RDF+ vermicompost+ biofertilizer + 4 spraying of (Zn+B+Fe)
T_5	RDF+ vermicompost+ biofertilizer + 6 spraying of (Zn+B+Fe)
T_6	RDF+ vermicompost+ biofertilizer + 8 spraying of (Zn+B+Fe)
T_7	vermicompost + biofertilizers +4 spraying of (Zn+B+Fe)
T_8	vermicompost + biofertilizers +6 spraying of (Zn+B+Fe)
T_9	vermicompost + biofertilizers +8 spraying of (Zn+B+Fe)
T_{10}	RDF through fertigation +4 spraying of (Zn+B+Fe)
T_{11}	RDF through fertigation +6spraying of (Zn+B+Fe)
T_{12}	RDF through fertigation + 8 spraying of (Zn+B+Fe)
T_{13}	Control

RDF: recommended fertilizer dose, Zn: Zinc, B: Boron, and Fe: Iron

Recommended fertilizer dose NPK is 800:400:400 gm/tree, As per the treatment half quantity of nitrogen and full quantity of phosphorus, potassium were applied in the mode of Urea, Single Super phosphate and Murate of potash respectively near the feeding root zone and mixed thoroughly in soil after release of water stress. Consequently the remaining half quantity of nitrogen was given one to one and half month, when fruit set. Zn+B+Fe: [Chelated zinc (0.5%) + Borax (0.2%) + Chelated Fe (0.5%)] applied in foliar spraying, and Vermicompost (3tonne/ha), Azotobacter (800ml/acre), PSB (800ml/acre), and Trichoderma(1kg/ha) were applied.

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Methodology

Harvesting was carried out at once. Yield in respects of number of fruit per tree, weight of fruit (kg/tree) and yield (kg ha^{-1}) was recorded. Observations on fruit size, fruit weight were based on random five fruit samples.

Six-to-seven month-old-leaves at 2nd, 3rd or 4th leaf position from non-fruiting terminals covering treatment trees at a height of 1.5-1.8 m from the ground were sampled (Srivastava *et.al.*, 1999). For leaf sampling nearly 80-100 leaves were assembled from each tree in 3-month interval i.e. Initial Observation, 2nd Observation (90 Days), 3rd Observation (180

Days) and 4th Observation Harvesting (270 Days) after the addition of fertilizer to the soil to the sweet orange

Result and Discussion

Effect of different nutrient management practices on yield parameters in sweet orange.

The data on number of fruits per tree, weight of fruit, volume of fruit and yield per tree presented in Table 1.

1. **Yield components of sweet orange**

The pooled data given in Table 1 referring to number of fruits, weight of fruit yield and volume of fruit per tree was observed statistically significant by the different management practices. The number of fruits per tree and fruit yield was increased from 48.25 to 206.50 and 29.58 to 51.34 kg/tree respectively at harvest. In pooled results it was evidenced that the highest fruit yield, weight of fruit and volume of fruit were achieved in treatment T_{12} i.e. application of RDF through fertigation plus vermicompost and biofertilizers with 8 numbers of spraying of zinc, boron and iron and at par with T_{11} which is RDF through fertigation plus vermicompost plus biofertilizers with 6 spraying of zinc, boron and iron and found significantly superior over all treatments. The least fruit yield was recorded with the treatment T_{13} (29.58 kg/tree) i.e. absolute control treatment. In case of weight of fruit treatment T_{12} recorded maximum fruit weight to the tune of 230.27 g and was at par with treatment T_{11}, T_7, T_6, T_{10}, T_9, T_5, T_4, T_3 and T_2, further this treatment was significantly superior over T_1 and T_{13}.

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Table No. 1. Effect of Different Nutrient Management Practices on Yield components of Sweet Orange

Treat. No.	Treatment	Pooled data			
		No. of Fruit / tree	**Wt. of Fruit (g)**	**Yield kg tree^{-1}**	**Vol. of fruits (cm^3)**
T_1	RDF+ 4 spraying of (Zn+B+Fe)	135.00	198.87	28.93	201.50
T_2	RDF+ 6 spraying of (Zn+B+Fe)	145.00	200.74	33.06	187.75
T_3	RDF+ 8 spraying of (Zn+B+Fe)	164.00	207.60	35.32	187.75
T_4	RDF+ Vermicompost+ biofertilizers + 4 spraying of (Zn+B+Fe)	155.00	209.13	35.82	200.00
T_5	RDF+ Vermicompost+ biofertilizers + 6 spraying of (Zn+B+Fe)	165.00	220.23	35.14	201.25
T_6	RDF+ Vermicompost+ biofertilizers + 8 spraying of (Zn+B+Fe)	171.00	224.96	37.21	200.50
T_7	Vermicompost + biofertilizers +4 spraying of (Zn+B+Fe)	136.00	204.24	28.87	176.50
T_8	Vermicompost + biofertilizers +6 spraying of (Zn+B+Fe)	152.00	208.67	30.35	189.00

T_9	Vermicompost + biofertilizers +8 spraying of (Zn+B+Fe)	161.00	215.16	32.35	182.00
T_{10}	RDF through fertigation + Vermicompost + biofertilizers + 4 spraying of (Zn+B+Fe)	171.00	215.98	38.24	205.00
T_{11}	RDF through fertigation + Vermicompost + biofertilizers + 6 spraying of (Zn+B+Fe)	196.00	225.47	47.54	203.25
T_{12}	RDF through fertigation + Vermicompost + biofertilizers + 8 spraying of (Zn+B+Fe)	226.00	230.27	51.34	212.00
T_{13}	Control	76.33	183.77	29.58	159.25
	S.Em.±	18.18	10.68	4.29	2.38
	C.D. at 5 %	52.68	28.79	12.87	6.91

The production of greater number of fruits in the treatments of application of bio-fertilizers with chemical fertilizers at different combination could be a consequence of the improvement in soil physical and chemical properties which in turn provided required nutrition for the transition of flowers to fruits resulting in higher fruit set ultimately, increasing the number of fruits per tree. These results are supported by findings of Borah *et al.* (2001) in khasi mandarine; Seshadri and Madhavi (2001) and Marathe (2005) in sweet orange. Similar finding reported by Desai et al., (2014) and Jakhar et al., (2016).

2. Leaf Macronutrient Concentration

The perusal data of presented in Table.2 stipulated that the leaf nitrogen, phosphorus, potassium and sulfur concentration of sweet orange orchard at different days of interval (90days, 180days and 270days) found to be influenced due to various treatments.

2.1 N, P, K and S

Nitrogen concentration in leaves at 90 days, 180 days and 270 days were ranged from 1 1.44 to 1.99 %, 1.46 to 2.16 %, and 1.43 to 2.09 % during pooled data respectively, and the phosphorous concentration in leaves increased from 90 days to 180 days i.e. 0.254 to 0.275 % and decreased at 270 days (0.265 %) during pooled data. The N and P concentration showed that, Treatment T_{12} was significantly superior, which receiving RDF through fertigation plus vermicompost plus biofertilizers plus 8 numbers of spraying of zinc, boron and iron, and at par with treatment T_{11} (RDF through fertigation + vermicompost + biofertilizers + 6 numbers of spraying of zinc, boron and iron)and T_6 (RDF + vermicompost + biofertilizers + 8 numbers of spraying of zinc, boron and iron) at different time interval. N, P, K and S concentration in leaves increased from 90 days to 180 days and gradually decreased at 270 days i.e after harvesting. At 180 days highest concentration observed due to normal function carried out by the plant as vegetative growth stage and flowering completed by that period (Jones and Parker, 1950). Such decline in leaf N content towards the end of season was as result of the conversion and accumulation of carbohydrates (Comeron, *et al.* 1952).

Highest potassium and sulfur concentration was registered with the treatment T_{12} (RDF through fertigation in addition to vermicompost and biofertilizers along with eight numbers of spraying of zinc, boron and iron) was 1.57, 1.62 and 1.61 % and 0.27, 0.32 and 0.30 mg kg^{-1} at 90 days, 180 days and 270 days, respectively during pooled mean, which is significantly superior over all treatments except T_{11} which receiving RDF through fertigation + vermicompost + biofertilizers + 6 numbers of spraying of zinc, boron and iron,. The accelerate in leaf nutrient content in different treatments receiving microbial fertilizers also suggests that these microbial fertilizers solubilize the available nutrient pool in the soil and improves the uptake of macro-nutrients, These results are in assent with the findings of Patel *et al*., (2009) who reported that nutrient uptake of N, P and K in sweet orange was enhanced with the application of 75% RDF + *Azotobacter* + AMF and micronutrients, and also Muzaffar. (2011) recorded highest N, P and K with conjoint application biofertilizers, vermicompost, FYM, green manure, sunhemp and RDF. The increased level of nitrogen and potassium content in leaf by foliar application of zinc may be an account of synergetic relationship with Zn (Kumar *et al.* 2017).

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3. Leaf Micronutrients Concentration

3.1 Zn, Cu, Fe, Mn and B concentration

Mean periodical micronutrients concentration in leaf was gradually increased with increasing growth of fruit up to 180 days and then it started to decline at 270 days during pooled data. In case of zinc, iron and boron the treatment T_{12} i.e. (RDF through fertigation + vermicompost + biofertilizers + 8 spraying of zinc, boron and iron) significantly superior at all growth observation followed by T_6 (RDF + vermicompost + biofertilizers + 8 spraying of Zn, Fe and B) over rest of treatments. The result proved that the micronutrients concentration boosted with treatment organic with inorganic fertilizer with frequent foliar application of micronutrients such as zinc, iron and boron in leaves of sweet orange. Seshadri and Madhavi (2001) showed an build up in Fe content in the leaves of sweet orange when treated with coupled application of organic and inorganic fertilizers. The increase in leaf nutrient composition in different treatments receiving microbial fertilizers also suggests that these microbial fertilizers solubilize the available nutrient pool in the soil and improves the uptake of micro-nutrients (Patel *et al.*, 2009).

Higher concentration of manganese and copper of leaves of sweet orange were found in treatment T_{12}, but did not reach to the level of significance. Lowest Cu and Mn concentration found in treatment T_{13}.These result are in equivalence with the result reported by Marathe *et al.* 2012.

Conclusion

Application of NPK in 8 splits with drip irrigation in addition to vermicompost @ 3 tonne ha^{-1} and biofertilizers i.e *Azotobacter* and PSB @ 2000 ml ha^{-1} each and trichoderma @ 1 kg ha^{-1} combined with 8 spraying of Zn (0.5%), Fe (0.5%) and B (0.2%) showed significantly higher yield and yield components whereas leaf concentration of nitrogen, phosphorus, potassium, sulfur, iron, zinc and boron significantly improved.

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Table No. 2. Effect of Different Nutrient Management Practices on Leaf Macronutrient Concentrationin Sweet Orange Orchard

Treat. No.	N%			P%			K%			S mg kg^{-1}		
	90 days	**180 days**	**270days**	**90 days**	**180 day**	**270days**	**90 days**	**180 days**	**270days**	**90 days**	**180 days**	**270days**
T_1	1.74	1.96	1.88	0.234	0.254	0.245	1.42	1.47	1.46	0.15	0.19	0.17
T_2	1.78	1.96	1.89	0.243	0.263	0.253	1.43	1.48	1.46	0.16	0.20	0.17
T_3	1.77	2.01	1.90	0.238	0.263	0.219	1.45	1.51	1.47	0.18	0.21	0.19
T_4	1.90	2.08	2.00	0.266	0.290	0.279	1.50	1.57	1.54	0.21	0.25	0.23
T_5	1.89	2.09	2.01	0.271	0.292	0.287	1.51	1.58	1.56	0.22	0.27	0.25
T_6	1.96	2.13	2.05	0.274	0.301	0.298	1.53	1.59	1.58	0.24	0.29	0.27
T_7	1.79	1.98	1.90	0.241	0.261	0.258	1.43	1.47	1.46	0.15	0.19	0.17
T_8	1.79	1.96	1.91	0.241	0.263	0.256	1.43	1.48	1.46	0.16	0.20	0.18
T_9	1.79	1.99	1.89	0.245	0.269	0.262	1.43	1.48	1.47	0.17	0.21	0.19
T_{10}	1.93	2.09	2.03	0.272	0.296	0.290	1.52	1.56	1.55	0.23	0.28	0.25
T_{11}	1.95	2.14	2.06	0.277	0.303	0.292	1.55	1.60	1.59	0.25	0.31	0.29
T_{12}	1.99	2.16	2.09	0.281	0.308	0.295	1.57	1.62	1.61	0.27	0.32	0.30
T_{13}	1.44	1.46	1.43	0.213	0.214	0.210	1.40	1.40	1.38	0.15	0.16	0.15
S.Em.±	0.018	0.011	0.015	0.003	0.006	0.007	0.008	0.010	0.009	0.003	0.004	0.003
C.D. at 5 %	0.052	0.032	0.042	0.007	0.016	0.020	0.024	0.029	0.026	0.011	0.013	0.009

Table No. 3. Effect of Different Nutrient Management Practices on Leaf Micronutrient Concentration in Sweet Orange Orchard

Treat. No.	Zn mg kg^{-1}			Fe mg kg^{-1}			Mn mg kg^{-1}			Cu mg kg^{-1}			B mg kg^{-1}		
	90 days	180 days	270 days	90 days	180 days	270 days	90 days	180 days	270 days	90 days	180 days	270 days	90 days	180 days	270 days
T_1	21.78	25.31	23.65	164.14	202.77	178.93	46.37	51.61	53.60	13.6	17.5	11.9	25.79	29.91	27.69
T_2	23.96	28.16	26.98	169.70	216.31	184.78	46.15	52.00	49.66	15.2	20.0	14.2	27.50	32.19	29.32
T_3	26.12	30.44	29.02	177.71	226.73	189.93	48.59	55.75	53.11	15.1	20.97	13.23	28.26	34.76	31.89
T_4	23.26	27.18	24.51	175.02	220.93	191.18	49.62	55.76	53.19	16.6	18.8	15.57	27.21	31.92	29.39
T_5	24.37	29.62	27.36	184.08	226.66	195.06	52.45	59.12	55.84	16.1	20.87	13.2	28.39	32.88	30.38
T_6	29.78	35.63	32.65	193.06	235.33	206.47	54.61	65.13	60.38	16.8	21.63	14.93	31.90	38.50	36.45
T_7	22.44	26.23	23.84	164.66	211.42	180.06	47.93	54.48	50.80	15.0	19.77	13.43	26.88	30.07	27.58
T_8	24.38	28.56	25.99	171.32	211.65	186.77	49.17	56.00	52.56	15.4	18.8	13.6	27.84	32.24	29.63
T_9	26.83	31.32	28.87	184.83	220.81	195.12	50.49	58.19	54.76	16.0	22.07	14.1	29.12	33.91	30.92
T_{10}	24.35	26.78	25.64	184.14	221.27	194.41	51.24	59.00	55.47	15.5	20.6	13.57	28.87	34.64	32.93
T_{11}	25.43	29.29	27.78	186.57	227.27	201.43	53.33	60.67	56.96	15.0	21.13	13.8	29.47	36.60	34.78
T_{12}	31.91	36.35	34.07	197.18	238.74	208.58	55.98	62.47	59.53	17.3	22.6	15.83	34.36	41.79	39.59
T_{13}	17.23	17.40	17.10	125.88	130.05	122.87	41.32	45.07	42.54	14.4	16.4	12.3	20.80	21.61	19.39
S.Em.±	1.61	1.63	1.66	3.45	3.58	3.31	2.15	2.75	1.84	1.21	1.32	1.29	1.65	1.62	1.63
C.D. at 5 %	4.63	4.75	4.94	10.29	10.61	9.58	NS	NS	NS	NS	NS	NS	4.81	4.74	4.79