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IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY ATTRIBUTES OF SWEET ORANGE (*CITRUS SINENSIS* L. OSBECK) CV. PHULE MOSAMBI

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Abstract

Effects of integrated nutrient management (INM) approach on the growth, yield, and quality of sweet orange [*Citrus sinensis* (L.) Osbeck] cv. Phule Mosambi was investigated. Eleven treatments were imposed in Complete Randomized Design (CRD) for two seasons (2019 and 2020) and among the treatments, T_{11} [50% RDN + 20kg FYM/tree + 25% N from Castor Cake + 10ml Bio NPK Consortium + Micronutrient foliar spray (1% Grade IV)] recorded the maximum incremental plant height (35.28 cm), plant spread N-S (45.73 cm), plant spread E-W (45.32 cm) and canopy volume (0.061m^3). Similarly treatment T_{11} significantly increased several yield parameters *viz*., the maximum fruit length (8.11cm), fruit diameter (7.96 cm), fruit weight (241.91 g), fruit volume (251.17 cc), no. of fruits per tree (255.17), yield (61.81 kg per tree and 17.18 t/ha) in pooled data. Amid quality traits, T_{11} stood significantly superior with respect to total sugar (6.99 %) content; it also showed higher sugar: acid ratio (14.27), ascorbic acid content (40.11 mg/100 ml pulp). Hence this particular treatment can be adopted preferably in sweet orange cultivation at middle Gujarat (India).

Introduction

Citrus fruits rank third in area and production after banana and mango in India. Sweet oranges being the second largest citrus fruit in terms of acreage, cultivated on large scale in Indian states like, Andhra Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Rajasthan. In India, sweet orange occupies an area of 187 thousand hectares and production of 3266 thousand metric tons (MT) has been achieved with a productivity of 17.46 MT/ha (Anon. 2019). Sweet orange [*Citrus sinensis* (L.) Osbeck] is a subtropical fruit, often described as only "Orange" is one of the most common and widely grown citrus fruit belonging to family Rutaceae and sub family Aurantioideae and native to Southern China. Columbus introduced them to the western hemisphere in the 15th century (Vashisth and Kadyampakeni , 2020). The orange tree is small, spiny tree, typically growing upto 4.5-5 m, generally with a compact crown. The fragrant white flowers are produced singly or in cluster. The flesh or pulp of the fruit is typically juicy and sweet, divided into 10 to 14 segments and ranges in colour from yellow to orange to red. Fruits are high in vitamin A, C and potassium. Fruits are eaten fresh or processed into juice, numerous desserts, jams and marmalades, etc.

Citrus fruit blooms sporadically in tropical areas, while it blooms profusely in subtropical areas after winter dormancy, resulting in only one main crop each year. Cultivar "Phule Mosambi", released from Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharasthra in the year 2008. Since then this variety has grabbed the grower's attention in neighboring state of Maharashtra. In the present study this variety was considered under Gujarat condition to come up with sustainable results regarding nutrient management for higher acceptability of this crop amid fruit growers of the region.

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Materials and Methods

The present experiment was conducted at Horticultural Research Farm, B.A. College of Agriculture, Anand Agricultural University, Gujarat, India. The place is at an elevation of 45.1 meters above mean sea level and is located at 22° 35' North latitude and 72° 56' East longitude, which is categorized under the Middle Gujarat agro climatic zone of Gujarat. The soil at the experimental site is alluvial in type, loamy, deep, well drained, and relatively moisture retentive. The experiment was laid out in completely randomized design considering the uniformity of 7 year old cv. Phule Mosambi plants (6 x 6 m) with eleven treatments *viz.*, [T_1: RDF {Recommended dose of fertilizer} (800:300:600 NPK g/tree) + 20kg FYM {Farm yard manure} (Control), T_2: 125% RDF + 20kg FYM/tree, T_3: 75% RDF + 20kg FYM/tree, T_4: 75% RDN + 20kg FYM/tree + 25% N from Vermicompost, T_5:75% RDN + 20kg FYM/tree + 25% N from Castor Cake, T_6:75% RDN + 20kg FYM/tree + 25% N from Vermicompost + 10ml Bio NPK Consortium, T_7:75% RDN + 20kg FYM/tree + 25% N from Castor Cake + 10ml Bio NPK Consortium, T_8:50% RDN + 20kg FYM/tree + 25% N from Vermicompost+ Micronutrient foliar spray (1% Grade IV), T_9:50% RDN + 20kg FYM/tree + 25% N from Castor Cake + Micronutrient foliar spray (1% Grade IV), T_{10}: 50% RDN+ 20kg FYM/tree + 25% N from Vermicompost + 10ml Bio NPK Consortium + Micronutrient foliar spray (1% Grade IV), T_{11}: 50% RDN + 20kg FYM/tree + 25% N from Castor Cake + 10ml Bio NPK Consortium + Micronutrient foliar spray (1% Grade IV)] and replicated thrice during the two years (2019 and 2020) of research. Common dose of 300 g phosphorus and 600 g potash per plant were given in the all treatments other than T_2 (375g Phosphorus, 750gm potash i.e., 125% RDF for P, K) and T_3 (225g Phosphorus, 450gm potash i.e., 75% RDF for P, K).Whereas, nitrogen dosage was varied among the treatments considering 800g as the recommended dose of nitrogen (RDN), rest of the calculation was done where 125, 75 and 50% was to be applied.

The chemical fertilizers were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MoP). Half dose of nitrogen, phosphorus and potash fertilizers were given as soil application in to all the plants by ring method after fruit set during the month of March. Remaining half dose of chemical fertilizers (NPK) was administrated in second fortnight of June month, as per treatment. RDF was adopted as per recommendation of MPKV Rahuri (Anon. 2018). Organic resources like, FYM, Vermicompost (1.74% N) and Castor Cake (4.80% N) was applied in June in order to address the supplementary demand of nitrogen. Bio NPK Consortium applied in 2 splits by soil drenching, 5 ml as basal dose in April, and remaining 5 ml after one month period. The consortium comprises of nitrogen fixing, phosphate solublizing and potash mobilizing five bacterial (*Azotobacter chrococcum, Azospirillium lipoferum, Bacillus tenqulansis, Bacillus licheniformis, Bacillus coagulans*) consortiums @ $5x10^8$ cfu/ml concentration. Micronutrient (Grade-IV: Fe- 4.0%, Mn- 1.0%, Zn- 6.0%, Cu- 0.5%, B- 0.5%) two spray was given, first in March and second spray one and half month after first spray. A multi micronutrient mixture which was available in powder form, dissolved into water at 1% concentration for spray.

During the experimental period, different growth parameters were recorded at initial stage of experiment (flowering- February; fruit set- March onwards) and at the end of each year (September), after harvest of fruits in order to get these observations on incremental basis e.g., incremental plant height (cm), incremental plant spread (cm) in north-south (N-S) and east-west (E-W) direction and incremental canopy volume (m^3). Canopy volume was calculated by using the following formula given by Westwood *et al.* (1963), i.e., canopy volume (m^3) = $4/3\pi a^2b$, where a = half of the plant height, b = average of east-west and north–south plant spread; considering sweet orange canopy as an oblate spheroid. Yield related observations like, fruit length (cm), fruit diameter (cm), fruit weight (g), fruit volume (cc), number of fruits per plant, fruit yield (kg per plant and t/ha) were also recorded. Several quality attributes were also measured from each season's fruit samples (five readings were taken in each replication of particular treatment and their average value was calculated) *viz.*, total soluble solids (°Brix) with digital refractrometer, acidity (%), total sugar (%), sugar/acid ratio was measured using methods described by Ranganna (1979). Juice content (%) of fruits was also recorded. The ascorbic acid content of the juice was determined titrametrically using the 2, 6- dichlorophenol indophenol dye as described by Ranganna, (1986). β-carotene (µg/100ml) was determined using water saturated n-butanol (n-butanol 6: water 2 v/v); a method described by Mishra and Gupta (1998).

Individual year's data of different parameters were analysed statistically. In order to study the overall effect of different treatments over the years, the pooled analysis was also carried out as suggested by Gomez and Gomez (1976). Treatment means of all characters for individual as well as pooled analysis were compared by means of critical differences at 5 % level of significance after employing 'F' test.

Results and Discussion

Growth parameters revealed that T_{11} [50% RDN+ 20kg FYM/tree + 25% N from Castor Cake + 10ml Bio NPK Consortium + Micronutrient foliar spray (1 % Grade IV)] resulted significantly higher value respect to incremental plant height (35.28cm), incremental plant spread (45.73cm, N-S and 45.32cm, E-S), incremental canopy volume (0.061 m^3) in pooled data; as well as in the year 2019 and 2020 (Table 1).The minimum incremental growth parameters were recorded in treatment T_3 (75% RDF+ 20kg FYM/tree).

Each plant cell requires an abundant supply of essential nitrogenous compounds for normal cell division, growth and respiration. Lovatt *et al.* (1988) reported that inoculation of nitrogen fixers such as *Azotobacter* and *Azospirillium* helps in fresh growth of shoot. *Azotobacter* has a direct influence on the development of plant root systems as well as the synthesis of plant growth regulators such as GA_3, IAA, and Cytokines (Gajbhiye *et al.*, 2003). Organic amendments (FYM, castor cake etc.) and micronutrients also play significant role in growth which mostly catalyzes chlorophyll production and also involve in some respiratory and photosynthetic enzyme systems. Enhanced photosynthetic rate and carbohydrate buildup; lengthens and widens the shoots, resulting in increased canopy volume. The present results are in agreement with the findings of Jain *et al.* (2012) in Nagpur mandarin, Borah *et al.* (2001) in Khasi mandarin, Ghosh *et al.* (2014) in sweet orange and Musmade *et al.* (2010) in lime.

Yield parameters in T_{11} showed a significant highest values of fruit length (8.11cm), fruit diameter (7.96 cm), fruit weight (241.91 g), fruit volume (251.17 cc), no. of fruits per tree (255.17), yield (61.81 kg per tree and 17.18 t/ha) in pooled data as well as in both the years (Table 2a and b). Influence of growth attributes were clearly observed in yield parameters. Treatment T_3 recorded minimum values regarding all yield parameters during experimental course.

Nitrogen supplemented by organic manures (castor cake, FYM and vermicompost) with a blend of chemical fertilizer promotes the development of plant vegetative conditions, resulting in the buildup of dry matter later translocated into fruit bearing regions, which ultimately improves the fruit's physical characteristics, volume, weight and also the number of fruits. The microbial consortia also aids in fruit development through partitioning dry matter towards sink for better yield by stimulating growth hormones. Foliar spray of micronutrients helps in promoting starch production and Mn, Zn, and B triggers quick transportation of carbohydrate in plants. Iron (Fe) is strongly linked to chlorophyll production, which in turn boosts photosynthesis. The present findings are in accordance with the results reported by Seshadri and Madhavi (2001), Jugnake *et al.* (2017) in sweet orange and Patel *et al.* (2012) in Kagzi lime.

Table 1. Effect of integrated nutrient management on growth parameters of *Citrus sinensis* (L.) Osbeck cv. Phule Mosambi.

Treatment		Incremental plant height (cm)			Incremental plant spread [n-s] (cm)			Incremental plant spread [e-w] (cm)			Incremental canopy volume (m^3)		
		2019	2020	POOLED	2019	2020	POOLED	2019	2020	POOLED	2019	2020	POOLED
T_1		26.77	26.83	26.80	36.33	38.33	37.33	36.92	36.73	36.83	0.028	0.029	0.028
T_2		32.30	32.67	32.48	41.50	43.87	42.68	42.45	42.57	42.51	0.046	0.049	0.048
T_3		25.63	24.67	25.15	35.33	35.17	35.25	35.78	34.57	35.18	0.024	0.023	0.024
T_4		27.70	29.67	28.68	39.00	39.67	39.33	37.85	39.57	38.71	0.031	0.037	0.034
T_5		28.73	29.33	29.03	38.90	40.43	39.67	38.88	39.23	39.06	0.034	0.036	0.035
T_6		31.40	31.83	31.62	41.10	41.97	41.53	41.55	41.78	41.67	0.043	0.045	0.044
T_7		33.53	31.57	32.55	42.53	42.17	42.35	43.64	41.53	42.59	0.051	0.044	0.048
T_8		32.17	32.47	32.32	41.90	42.37	42.13	42.30	42.36	42.33	0.046	0.048	0.047
T_9		30.50	30.40	30.45	39.13	41.40	40.27	40.72	39.97	40.34	0.039	0.041	0.040
T_{10}		33.50	34.83	34.17	44.60	45.47	45.03	43.75	44.31	44.03	0.053	0.058	0.055
T_{11}		34.83	35.73	35.28	45.07	46.40	45.73	44.94	45.70	45.32	0.058	0.064	0.061
Treatment (T)	SEM ±	1.51	1.71	1.14	1.66	1.72	1.19	1.49	1.71	1.13	0.006	0.007	0.004
	c. d. (p =0.05)	4.42	5.02	3.25	4.87	5.04	3.40	4.38	5.01	3.23	0.017	0.020	0.012
Year (Y)	SEM ±	-	-	0.48	-	-	0.51	-	-	0.48	-	-	0.002
	c. d. (p =0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YxT	SEM ±	-	-	1.61	-	-	1.69	-	-	1.60	-	-	0.006
	c. d. (p =0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
C.V. %		8.52	9.59	9.08	7.10	7.16	7.13	6.34	7.25	6.81	23.840	27.721	25.942

Table 2a. Effect of integrated nutrient management on yield parameters of *Citrus sinensis* (L.) Osbeck cv. Phule Mosambi.

Treatment		Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)			Fruit volume (cc)		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1		7.34	7.50	7.42	7.37	7.41	7.39	202.20	213.40	207.80	213.94	218.28	216.11
T_2		7.75	7.75	7.75	7.45	7.57	7.51	207.19	218.31	212.75	220.98	229.00	224.99
T_3		7.02	7.43	7.23	7.24	7.32	7.28	200.29	203.67	201.98	208.00	209.67	208.83
T_4		7.57	7.47	7.52	7.43	7.63	7.53	212.51	210.56	211.54	220.89	217.56	219.22
T_5		7.90	7.24	7.57	7.38	7.44	7.41	218.43	230.67	224.55	225.00	237.67	231.33
T_6		7.78	7.79	7.78	7.52	7.59	7.56	226.00	233.08	229.54	231.89	243.33	237.61
T_7		7.61	7.37	7.49	7.93	7.82	7.88	224.15	232.92	228.54	229.00	235.67	232.33
T_8		7.87	7.88	7.87	7.90	7.89	7.90	220.48	229.00	224.74	240.78	240.33	240.56
T_9		7.59	7.63	7.61	7.83	7.84	7.83	236.00	233.00	228.17	243.33	227.33	235.33
T_{10}		7.72	8.17	7.95	7.54	7.75	7.64	239.69	237.00	238.34	246.33	248.33	247.33
T_{11}		7.97	8.25	8.11	7.97	7.95	7.96	243.15	240.67	241.91	253.00	249.33	251.17
Treatment (T)	SEM ±	0.18	0.20	0.13	0.17	0.14	0.11	9.18	7.97	6.08	9.11	8.68	6.29
	C. D. (p =0.05)	0.52	0.59	0.38	0.50	0.41	0.31	26.94	23.39	17.34	26.72	25.46	17.93
Year (Y)	SEM ±	-	-	0.06	-	-	0.05	-	-	2.59	-	-	2.68
	C. D. (p =0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
Y x T	SEM ±	-	-	0.19	-	-	0.15	-	-	8.60	-	-	8.90
	C. D. (p =0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
C.V. %		4.05	4.53	4.30	3.86	3.13	3.51	7.20	6.12	6.67	6.85	6.46	6.66

Table 2b. Effect of integrated nutrient management on yield parameters of *Citrus sinensis* (L.) Osbeck cv. Phule Mosambi.

Treatment		No. Of fruits per tree			Yield (kg per tree)			Yield (tons/ha)		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1		197.33	193.67	195.50	39.95	41.23	40.59	11.11	11.46	11.28
T_2		203.33	210.00	206.67	42.04	45.65	43.85	11.69	12.69	12.19
T_3		184.00	191.67	187.83	36.89	39.06	37.98	10.26	10.86	10.56
T_4		199.67	207.67	203.67	42.38	43.78	43.08	11.78	12.17	11.98
T_5		198.33	201.00	199.67	43.38	46.38	44.88	12.06	12.89	12.48
T_6		206.33	206.67	206.50	46.64	48.19	47.41	12.97	13.40	13.18
T_7		205.00	202.33	203.67	45.96	47.19	46.57	12.78	13.12	12.95
T_8		226.00	229.33	227.67	50.08	52.36	51.22	13.92	14.56	14.24
T_9		216.67	215.00	215.83	51.34	50.29	50.81	14.27	13.98	14.13
T_{10}		239.00	236.33	237.67	57.26	55.96	56.61	15.92	15.56	15.74
T_{11}		256.00	254.33	255.17	62.42	61.20	61.81	17.35	17.01	17.18
Treatment (T)	SEM ±	8.63	8.64	6.11	3.26	2.53	2.07	0.90	0.70	0.57
	C. D. (p =0.05)	25.31	25.34	17.40	9.58	9.09	5.89	2.66	2.06	1.64
Year (Y)	SEM ±	-	-	2.60	-	-	0.88			0.24
	C. D. (p =0.05)	-	-	NS	-	-	NS			NS
YxT	SEM ±	-	-	8.64	-	-	2.92			0.81
	C. D. (p =0.05)	-	-	NS	-	-	NS			NS
C.v. %		7.05	7.01	7.03	12.00	9.08	10.60	12.00	9.08	10.60

Table 3a. Effect of integrated nutrient management on quality parameters of *Citrus sinensis* (L.) Osbeck cv. Phule Mosambi.

Treatment		Tss(°brix)			Acidity (%)			Total sugar (%)			Sugar : acid ratio		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1		8.67	8.95	8.81	0.580	0.590	0.585	6.68	6.49	6.58	11.62	11.13	11.37
T_2		8.73	8.76	8.75	0.527	0.523	0.525	6.74	6.73	6.73	12.91	12.91	12.91
T_3		8.93	8.93	8.93	0.570	0.553	0.562	6.03	6.05	6.04	10.58	10.94	10.76
T_4		8.90	9.13	9.02	0.553	0.537	0.545	6.72	6.77	6.75	12.26	12.66	12.46
T_5		9.50	8.84	9.17	0.510	0.507	0.508	6.55	6.52	6.54	12.94	12.92	12.93
T_6		9.33	8.93	9.13	0.530	0.523	0.527	6.78	6.63	6.70	13.00	12.87	12.93
T_7		9.43	9.05	9.24	0.587	0.470	0.528	6.84	6.83	6.83	11.75	14.57	13.16
T_8		9.57	9.53	9.55	0.597	0.690	0.643	6.30	6.36	6.33	10.63	9.26	9.94
T_9		9.77	9.88	9.83	0.690	0.610	0.650	6.56	6.52	6.54	9.59	10.85	10.22
T_{10}		9.78	9.75	9.77	0.470	0.513	0.491	6.80	6.81	6.81	14.53	13.41	13.97
T_{11}		9.60	9.40	9.50	0.490	0.507	0.498	6.99	7.00	6.99	14.65	13.90	14.27
Treatment (T)	SEM ±	0.27	0.25	0.19	0.039	0.038	0.027	0.17	0.16	0.12	0.90	0.84	0.61
	C. D. (p =0.05)	0.79	0.74	0.53	0.114	0.111	0.077	0.50	0.48	0.34	2.66	2.45	1.76
Year (Y)	SEM ±	-	-	0.08	-	-	0.012	-	-	0.05	-	-	0.26
	C. D. (p =0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
Y x T	SEM ±	-	-	0.26	-	-	0.039	-	-	0.17	-	-	0.87
	C. D. (p =0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
C.V. %		5.05	4.77	4.91	12.204	12.03	12.119	4.47	4.43	4.40	12.86	11.79	12.33

Table 3b. Effect of integrated nutrient management on quality parameters of *Citrus sinensis* (L.) Osbeck cv. Phule Mosambi.

Treatment		Juice (%)			Ascorbic acid (mg/100 ml)			ß-carotene (μG/100 ml)		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1		44.17	43.57	43.87	34.00	35.33	34.66	15.06	15.26	15.16
T_2		48.22	47.60	47.91	34.20	36.20	35.20	16.35	16.42	16.39
T_3		42.87	42.87	42.87	33.33	32.34	32.84	15.94	16.08	16.01
T_4		43.31	43.35	43.33	36.15	35.02	35.59	18.63	18.94	18.79
T_5		42.99	43.99	43.49	34.46	33.89	34.17	17.45	17.77	17.61
T_6		43.34	43.99	43.66	38.41	37.06	37.74	17.70	17.87	17.78
T_7		44.30	45.76	45.03	37.85	36.75	37.30	16.60	16.65	16.62
T_8		50.37	49.81	50.09	40.77	39.43	40.10	18.15	18.32	18.24
T_9		49.18	48.87	49.03	38.98	37.26	38.12	17.97	17.73	17.85
T_{10}		46.84	48.17	47.50	40.28	39.91	40.10	19.80	19.87	19.83
T_{11}		49.72	48.98	49.35	41.12	39.10	40.11	19.42	19.59	19.50
Treatment (T)	SEM ±	1.95	1.70	1.29	1.44	1.43	1.02	0.89	0.82	0.60
	C. D. (P =0.05)	5.72	4.98	3.69	4.23	4.21	2.91	2.62	2.40	1.73
year (Y)	SEM ±	-	-	0.55	-	-	0.43	-	-	0.25
	C. D. (P =0.05)	-	-	NS	-	-	NS	-	-	NS
Y x T	SEM ±	-	-	1.81	-	-	1.44	-	-	0.85
	C. D. (P =0.05)	-	-	NS	-	-	NS	-	-	NS
C.V. %		7.36	6.39	6.89	6.72	6.81	6.77	8.84	8.03	8.44

In the present study (Table 3a and 3b) provides an insight regarding the impact of different INM (Integrated nutrient management) treatments with regard to fruits quality characters, significantly maximum pooled TSS content (9.83°Brix) was observed in T_9 (Table 3a and b). Significantly minimum acidity content (0.491 %) and high β-carotene (19.83 µg/100 ml) content, which are considered as one of the important nutritive index for orange juice were recorded in treatment T_{10}. Juice content was recorded significantly maximum (50.09%) in T_8. Consistent significant results were observed in T_{11} regarding total sugar (6.99 %) content; a higher sugar: acid ratio (14.27) and a significantly higher ascorbic acid content (40.11 mg/100 ml pulp).

Biochemical quality indices and juice contents are influenced by various integrated nutrient management (INM) treatments; increased juice % may be attributable to increased water and nutrient absorption, as well as an increase in the amount of intercellular gaps in the juice pulp. Supply of growth promoting substances like, GA_3 through various INM treatments may enhance juice content by promoting cell division and cell elongation. Boron, on the other hand, is involved in sugar translocation and carbohydrate metabolism. As a borate complex, the sugars are more easily transferred across the cell membrane. Greater availability of dry matter for sugar conversion was also aided by microbial and organic inputs. Ghosh and Besra (2000), Kumar *et al.* (2017) and Singh *et al.* (2018) in sweet orange also reported findings in close agreement with the results of present study. Lower acidity in fruits may be attributed to their conversion into sugars and their derivatives via processes involving reversal of the glycolytic pathway, or it may be employed in respiration. Micronutrients like zinc aids in enzymatic responses such as carbohydrate transformation, hexokinase activity, cellulose production, and sugar change owing to its impact on zymohexose (Dutta and Dhua 2002). Results are close to the findings of Venu *et al.* (2014) in acid lime.

The incorporation of micronutrients resulted in significantly higher ascorbic acid levels which could be attributed to catalytic activity of zinc, iron, and boron on its biosynthesis from its precursor (glucose-6-phosphate) or suppression of its conversion into dehydro ascorbic acid by oxidising enzyme, or both (Abhijith *et al*. 2018). In lime, Lal and Dayal (2014) reported similar supporting results in case of ascorbic acid content. Wide range of variation in β-carotene content observed across different *Citrus* spp. Proper uptake may lead to increase in pigment synthesis, resulting higher carotenoids in juice of sweet orange. Similar results were reported by Gichuhi *et al.* (2014) regarding influence of organic amendments. Pritwani and Mathur (2017) also reported similar content of β-carotene (µg/100ml) in orange in India.

From the two years of field study, it may be concluded that by application of 50% RDN (400g N) + 20kg FYM/tree + 25% N from Castor Cake (4.2kg Castor Cake) + 10ml Bio NPK Consortium + Micronutrient foliar spray (1% Grade IV) per tree [T_{11}] in sweet orange cv. Phule Mosambi can enhance growth and yield contributing parameters resulting improved quality of fruits.

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