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Effect of biofertilizer and chemical fertilizer on growth and yield of sweet orange (*Citrus sinensis* L. Osbeck)

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Abstract
The present investigation was carried out at sweet orange research station Badnapur, district Jalna on eight year old sweet orange plant during Mrig bahar (May- June) in the year 2015-16 to study the effect of biofertilizer and chemical fertilizer on growth and yield of sweet orange (*Citrus sinensis* L. Osbeck). The experiment was laid out with seven treatments having different combination of biofertilizers and chemical fertilizers (i.e. PSB, Azotobacter, 800:400:400g NPK and 50kg FYM) in Randomized block design with three replications. The maximum increase in tree height (0.47m), stem girth (4.16 cm), tree spread (E-W 0.37m and N-S 0.50m) was recorded in the treatment of RDF (800:400:400g NPK+ 50kg FYM) + 80ml Azotobacter + 80ml PSB (T_6). The maximum increase in plant volume (10.36m^3) was observed in the treatment of RDF (800:400:400g NPK + 50kg FYM) + 80ml PSB (T_5). The maximum increase in number of fruits (403.83), average yield (107.36kg) and marketable yield of fruits (105.46kg) was recorded in the treatment of RDF (800:400:400g NPK + FYM) + 80ml Azotobacter + 80ml PSB (T_6).

Keywords: biofertilizer, chemical fertilizer, *Citrus sinensis* L, marketable yield

Introduction
Citrus fruits are one of the most delicious fruits belonging to the family Rutaceae. All commercially important species belong to genus citrus including Sweet orange, Mandarin, Kagzi lime, Lemon, Sweet lime, Grape fruit, etc. Sweet orange is originated from southern China where it has been cultivated for many years (Nicolosi, 2007) [14]. But today it is grown commercially worldwide in tropical, sub-tropical and some temperate regions to become the most widely planted fruit tree in the world. In India area (334.94 thousands ha) and production is about (3886.20 thousands MT) respectively. Maharashtra state is the third largest producer of Sweet orange (18%), after Telangana (43%) and Andhrapradesh (34%) respectively. The Maharashtra state produces 172.5 thousand MT of Sweet orange from an area of 95.0 thousand ha having productivity of 7.5 MT/ha. The production of citrus is concentrated in the belts of Jalna, Aurangabad, Parbhani, Nanded and Beed districts of Maharashtra state (Anonymous, 2014) [5]. Jalna district is a leading producer in Sweet orange production and productivity in Maharashtra state and in Marathwada region. The Jalna district have an area (13000ha), production (299000 MT) and productivity (23 MT/ha) of Sweet orange respectively (Bawne and Khan, 2015) [7]. Biofertilizers are supposed to be safe alternatives to chemical fertilizers to minimize the ecological disturbance. Biofertilizers are cost effective, eco-friendly and when they are required in bulk can be generated at the farm itself. They increase crop yield by 10-40 percent and fix nitrogen up to 40-50 percent. The other plus point is that after using 34 years continuously. There is no need of application of biofertilizers because partial inoculums are sufficient for growth and manipulation. They improve soil texture, pH and other properties of soil (Youseef and Eissa, 2014) [27].

Material and methods
The experiment was conducted on eight year old Sweet orange (Variety Nucellar) trees with uniform growth. They were spaced at 6 x 6 meters. An experiment was started in Mrig bahar (May – June) in year 2015. The design of experiment was Randomized block design with seven treatments viz. T_1 – Chemical fertilizer (800:400:400g NPK) + 80 ml Azotobacter, T_2 – Chemical fertilizer (800:400:400g NPK) + 80ml PSB, T_3 – Chemical fertilizer (800:400:400g NPK) + 80ml Azotobacter + 80ml PSB, T_4 – RDF (800:400:400g NPK + 50kg FYM) + 80ml

T_7 – (Control) RDF (800:400:400g NPK + 50kg FYM) and was replicated trice. The plot unit for each treatment consists of four trees. Well rotten FYM was applied to the respective plots as per the treatment at beginning. Half dose of Nitrogen and full dose of Phosphorous and Potassium were applied in the form of Urea, Single super phosphate and Murate of potash in the month of June – 2015. Remaining half dose of Nitrogen was given one and half month after application of biofertilizers such as Azotobacter and PSB. The data on tree height, stem girth, plant spread was were recorded using meter scale and plant volume was recorded by the following formula.

Canopy volume = $0.5236 \times H \times D^2$

Were,
H = Height of plant (m)
D^2 = Plant spread in
N-S and E–W (m)

The number of fruits was recorded by counting the fruits per tree at the time of harvesting. Average yield and marketable yield of fruits were recorded by using the electric weighing open pan balanced. The data obtained on various characters were subjected to stastical analysis and interpretation of the data was carried out in accordance to Panse and Sukhatme (1995) [15].

Result and discussion

The data regarding the tree height and stem girth are presented in Table 1. The maximum increase in tree height (0.47m) and stem girth (4.16cm) was recorded in the treatment of RDF (800:400:400g NPK + 50kg FYM) + 80ml Azotobacter + 80ml PSB (T_6). Whereas the minimum increase was observed in control (T_7). The increase in plant height could be attributed to the higher uptake of nutrients, particularly nitrogen. These findings are in accordance with (Annual report- 2006-07) reported that maximum increase in plant height (8.32%) with treatment FYM + VC + AM fungi + Azotobacter + Azospirillum in mango. (Annual report- 2009-10) In mandarin, acid lime at Akola and sweet orange at Tirupati inorganic and biofertilizer was found better for vegetative growth. (Ismail *et al*., 2011) [9] showed that applying bacteria like Azotobacter, Bacillus and algae extraction as soil application of biofertilizers have ability to stimulate bitter orange growth. (Yadav e. al., 2012) [26] reported that medium combination of soil + sand + vermicompost + vermiculite + cocopeat (1:1:1:1:1) with Azotobacter Had significantly increased the height and stem diameter in acid lime. (Patil and Shinde., 2013) [17] recorded maximum plant height and plant girth in banana by application of 50% RDF (200:160:200g NPK) + FYM + 50g Azotobacter + 50g PSB + 250g VAM (Annual report- 2013-14) the application of FYM (7.5 t/ha) + vermicompost (3.18 t/ha) + PSB (5kg) + Azotobacter (5kg/ha) showed remarkable result in growth parameter of strawberry. (Lenka and Lenka., 2014) [11] observed the inorganic and biofertilizers served the maximum plant height and stem girth in banana cv. Grand naine. (Sharma and Bhatnagar., 2014) [18] revealed the inorganic fertilizer, vermicompost and biofertilizer have maximum plant height, rootstock girth, scion girth and plant spread of apple cv. Arka sahan.

Table 1

Tr. No.	Tree height (m)			Stem girth		
	Initial	final	Increase	Initial	final	Increase
T_1	3.42	3.72	0.29	40.20	43.08	2.88
T_2	3.58	3.92	0.33	43.22	46.34	3.11
T_3	3.34	3.74	0.39	50.91	54.11	3.20
T_4	3.38	3.81	0.43	44.91	48.24	3.32
T_5	3.57	4.03	0.45	45.34	48.76	3.42
T_6	3.48	3.95	0.47	45.04	49.20	4.16
T_7	3.49	3.75	0.26	47.14	49.62	2.48
S.E. +	-	-	0.05	-	-	0.27
C.D. at 5%	-	-	0.14	-	-	0.85

The data regarding tree spread and plant volume are presented in Table 2. The maximum increase in East-West tree spread (0.37m) was recorded in the treatment of RDF (800:400:400g NPK + 50kg FYM) + 80ml Azotobacter + 80ml PSB (T_6) which was stastically at par with T_5 and T_4 where as the minimum increase (0.22 m) was observed in control (T_7).

The maximum increase in North- South tree spread (0.50m) was recorded in the treatment of RDF (800:400:400g NPK+ 50kg FYM) + 80ml Azotobacter + 80ml PSB (T_6) which was stastically at par with T_5 and T_4 while the minimum increase (0.29 m) was observed in control (T_7).

The data showed that, the maximum increase in plant volume ($10.36m^3$) was recorded in the treatment of RDF (800:400:400g NPK + 50kg FYM) + 80ml PSB (T_5) and it was stastically at par with T_6, T_4, and T_3 where as the minimum increase ($5.76\ m^3$) was recorded in control (T_7). The increase in plant volume and plant spread may be due to the increase in shoot length and number of leaves which might have resulted in production of more quantum of carbohydrates and subsequently their translocations towards the branches and plant volume. (Khehra and Bal., 2014) [10] reported that FYM, inorganic fertilizer and biofertilizers are to be increased the plant height, stem girth and spread of lemon cv. Baramasi. (Nazir *et al*., 2015) [13] studied the treatment combination of poultry manure, biofertilizer, wood ash and mustard oil cake significantly improved the plant height and plant spread of strawberry cv. Senga sengana.

Table 2

Tr. No.	Plant spread (m)						Plant volume (m^3)		
	East-West			North-South					
	Initial	final	Increase	Initial	final	Increase	Initial	final	Increase
T_1	3.62	3.88	0.26	3.66	4.00	0.33	23.59	30.11	6.50
T_2	3.67	3.94	0.27	3.65	4.00	0.35	25.34	32.46	7.13
T_3	3.52	3.82	0.29	3.74	4.11	0.37	23.14	31.23	8.10
T_4	3.44	3.76	0.31	3.58	4.00	0.41	22.54	30.73	8.20
T_5	3.94	4.29	0.35	3.90	4.35	0.45	29.45	39.83	10.36
T_6	3.60	3.97	0.37	3.49	3.99	0.50	23.37	33.59	10.23
T_7	3.59	3.82	0.22	3.57	3.86	0.29	23.99	29.75	5.76
S.E. +	-	-	0.03	-	-	0.04	-	-	0.94
C.D. at 5%	-	-	0.08	-	-	0.12	-	-	2.89

The data regarding number of fruits, average yield and marketable yield of fruits are presented in Table 3. The maximum number of fruits per tree (403.83) was produced by the treatment of RDF (800:400:400g NPK + 50kg FYM) + 80ml Azotobacter + 80ml PSB (T_6) and it was stastically at par with T_5, T_4 and T_3. The minimum number of fruits per tree (363.60) was recorded in the control (T_7). (Annual report- 2006-07) reported more number of fruits and yield with treatment combination of FYM, Vermicompst, Azotobacter and PSB in mango cv. Amrapali.

Table 3

Tr. No.	Number of fruits	Average yield (kg)	Marketable yield (kg)
T_1	369.46	88.70	85.60
T_2	379.46	92.90	90.36
T_3	382.53	95.86	93.43
T_4	388.43	98.53	96.26
T_5	395.93	102.00	99.70
T_6	403.83	107.36	105.46
T_7	363.60	86.66	81.63
S.E. +	7.49	3.57	3.59
C.D. at 5%	23.09	11.00	11.07

The highest average yield (107.36kg) and marketable yield (105.46kg) of fruits was recorded in the treatment of RDF (800:400:400g NPK + 50kg FYM) + 80ml Azotobacter + 80ml PSB (T_6) and it was stastically at par with T_5 and T_4 while the lower average yield and marketable yield was recorded in the control (T_7). (Annual report- 2006-07) reported addition of VAM, PSB, Azospirillum, T. harzianum and RDF produced the highest yield of sweet orange at Rahuri. (Umer *et al*., 2009) [24] observed the Azotobacter and 100% N through urea increases the fruit weight and yield of Strawberry cv. Chandler. (Bhalerao *et al*., 2009) [8] found that application of 100% NPK with 10kg FYM, Azospirillum and PSB beneficial for yield of banana. (Annual Report- 2009-10) at Tirupati, 75% of RDF along with AM, PSB, Azospirillum and T. harzianum recorded the better yield of sweet orange. (Barne *et al*., 2011) [6] recorded the maximum fruit and yield per plant by application of NPK, FYM, Azotobacter, and PSB in guava. (Singh *et al*., 2012) [21] and (Singh and Saravanan, 2012) [20] recorded the highest number of fruits and fruit yield by biofertilizers in strawberry cv. Chandler. (Trivedi *et al*., 2012) [23] revealed that the biofertilizers Azotobacter and PSB per plant recorded higher fruit yield in guava. (Verma and Rao., 2013) [25] reported that the Azotobacter, PSB, Vermicompost and 50% RDF showed higher number of fruits, marketable yield and total yield in strawberry. (Meena *et al*., 2013) [12] observed the 2/3rd of RDF, FYM and Azotobacter significantly increased the number of fruits and yield of guava orchard. (Tripathi *et al*., 2014) [22] observed that Azotobacter and PSB each at 6kg/ha fertilized strawberry trees achieving the maximum yield. (Singh, 2015) [19] reported the application of vermicompost, Azotobacter, PSB and AM showed significantly higher yield per plant of strawberry.

Conclusion

The result and discussion of the present study showed that, the different combination of bio-fertilizers and chemical fertilizers have a significant influence on growth and yield of sweet orange production.

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