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Effect of bio-fertilizer and chemical fertilizer on yield and quality 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 yield and quality 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 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). The maximum increase in quality parameters were recorded in the treatment of RDF (800:400:400g NPK + FYM) + 80ml Azotobacter + 80ml PSB (T_6) i.e. Juice percent (52.33%), TSS (12.60^0 Brix), total sugar percent (8.80%), reducing sugar percent (4.48%), non-reducing sugar percent (4.33%) and ascorbic acid content (58.70 mg/100ml juice).

Keywords: bio-fertilizer, chemical fertilizer, *Citrus sinensis* L.

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) [12]. 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 Andhra Pradesh (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) [3]. 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) [6]. 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) [21].

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

Azotobacter, T_5 – RDF (800:400:400g NPK + 50kg FYM) + 80ml PSB, T_6 – RDF (800:400:400g NPK + 50kg FYM) + 80ml Azotobacter + 80ml PSB, 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 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 juice was extracted by a juice extractor and percentage was calculated as per the following formula,

$$\text{Juice (\%)} = \frac{\text{Weight of juice}}{\text{Weight of fruit}} \times 100$$

The total soluble solids (TSS) of freshly extracted juice were ascertained by "Hand Refractometer" (0-32^0 Brix) at room temperature. Total sugar was calculated by the following formula,

Total sugar percentage was calculated as per the following formula,

$$\text{Total sugar (\%)} = \text{Reducing sugar (\%)} + \text{Non-reducing sugar (\%)}$$

Reducing sugar and non-reducing sugar percentage was calculated by the Benedict method (Anonymous, 2014) [3], Ascorbic acid (Vitamin C) content of juice was estimated by the 2, 6 – dichlorophenol indophenols dye method which mentioned in (Anonymous, 2014) [4]. 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) [13].

Result and discussion

The data regarding number of fruits, average yield and marketable yield of fruits are presented in Table 1. 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 1

Tr. No.	Number of fruits per plant	Average yield of fruits per plant	Marketable yield of fruits per plant
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. $\pm$	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) [19] observed the Azotobacter and 100% N through urea increases the fruit weight and yield of Strawberry cv. Chandler. (Bhalerao *et al*., 2009) [7] 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) [5] recorded the maximum fruit and yield per plant by application of NPK, FYM, Azotobacter, and PSB in guava. (Singh *et al*., 2012) [16] and (Singh and Saravanan, 2012) [15]. recorded the highest number of fruits and fruit yield by biofertilizers in strawberry cv. Chandler. (Trivedi *et al*., 2012) [18] revealed that the biofertilizers Azotobacter and PSB per plant recorded higher fruit yield in guava. (Verma and Rao., 2013) [20] 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) [10] observed the 2/3rd of RDF, FYM and Azotobacter significantly increased the number of fruits and yield of guava orchard. (Tripathi *et al*., 2014) [17] observed that Azotobacter and PSB each at 6kg/ha fertilized strawberry trees achieving the maximum yield. (Singh., 2015) [14] reported the application of vermicompost, Azotobacter, PSB and AM showed significantly higher yield per plant of strawberry.

Table 2

Tr. No.	Percent of juice	TSS (^{0}Brix)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)	Ascorbic acid (mg/100ml)
T_1	44.00	10.70	5.30	2.86	2.46	48.00
T_2	44.06	10.83	5.70	3.03	2.60	48.23
T_3	46.56	11.73	6.96	3.93	3.03	53.43
T_4	47.50	12.13	6.33	3.43	2.90	55.43
T_5	48.30	12.53	6.83	3.76	3.03	56.63

T_6	52.53	12.66	8.80	4.43	4.33	58.70
T_7	40.73	10.43	4.80	2.30	2.50	43.70
S.E. ±	0.68	0.27	0.15	0.11	0.07	0.28
C.D. at 5%	2.09	0.83	0.47	0.35	0.22	0.87

The data regarding juice percentage, TSS, total sugar, reducing sugar, non reducing sugar and ascorbic acid content are presented in Table 2. The maximum juice percentage (52.53%) was recorded in the treatment of RDF (800:400:400 g NPK + 50 kg FYM) + 80 ml *Azotobacter* + 80 ml PSB (T_6) and it was superior over the rest of the treatments, while, the minimum juice percentage (40.73%) was recorded in the control (T_7).

The maximum TSS (12.66^0 Brix) was observed in the treatment of RDF (800:400:400 g NPK + 50 kg FYM) + 80 ml *Azotobacter* + 80 ml PSB (T_6), which was stastically at par with T_5 and T_4. Where, as the minimum TSS (10.43^0 Brix) was observed in control (T_7)

The maximum total sugar (8.80%), reducing sugar (4.43%), non reducing sugar (4.33%) and ascorbic acid content (58.70 mg/100ml juice) was recorded in the treatment of RDF (800:400:400 g NPK + 50 kg FYM) + 80 ml *Azotobacter* + 80 ml PSB (T_6) and it was superior over rest of the treatments, while, the minimum total sugar (4.80%), reducing sugar (2.30%), non reducing sugar (2.50%) and ascorbic acid content (43.16 mg/100ml juice) was observed in control (T_7).

The improved fruit quality may be attributed to better vegetative growth of the treated plants, which resulted in higher quantities of photosynthates (starch, carbohydrate etc.) and translocation to the fruits thus increasing the contents of various fruits quality parameters (Dutta *et al*. 2014 and Mir *et al*.2015) [8, 11].

The quality improvement in fruits may be due to proper supply of nutrients and induction of growth hormones, which stimulated cell division, cell elongation, increase in number and weight of fruits, better root development and better translocation of water uptake and deposition of nutrients. This might be attributed due to the improved fertilizer use efficiency with the application of organic sources of nutrients reported by (Lal and Dayal, 2014) [9] in acid lime.

Conclusion

The result and discussion of the present study showed that, the different combination of bio-fertilizers and chemical fertilizers have a significantly best for yield and significantly superior for most of the quality parameters of sweet orange production.

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