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Influence of combined use of organic, inorganic and biological sources of nutrients in sweet orange

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Abstract
The present investigation entitled "Influence of combined use of organic, inorganic and biological sources of nutrients in Sweet orange" was carried out to find out the suitable combinations of organic, inorganic manures, bio-fertilizers for higher yield and better fruit quality in sweet orange. A field experiment was laid out in Randomized Block Design (RBD) during 2011-2013 with nine treatments replicated thrice.

The yield contributing characteristics *viz.*, number of flower Shoot^{-1}, number of fruit Shoot^{-1} and fruit set per cent influenced significantly due to different nutrient management treatments. The maximum fruit yield was recorded in treatment T_7 (75% Rec. N (900 g N/tree) + 25 % N through Neem cake + Bio fertilizers (AM +PSB @ 100 g/tree). The fruit chemical parameters *i.e.*, highest TSS was recorded in treatment T_5 (75% Rec. N (900 g N/tree) + 25 % N through FYM + Bio-fertilizers (AM+PSB @ 100 g/tree) while highest ascorbic acid content was recorded in treatment T_8 (100% Rec. N, P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @100 g/tree). As in treatment T_8 (100% Rec. N,P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @ 100 g/tree) had highest B:C ratio because of no organics which resulted in lowering the cost and ultimately reflecting higher B: C ratio.

Keywords: Sweet orange, FYM, inorganic fertilizer, biofertilizer, quality, yield

Introduction
Citrus fruits have important position among other popular fruit of the world. In India, common citrus fruits grown are mandarins, sweet orange, limes and lemons comprising 45, 25, 15 and 10 per cent area respectively. But they have only 13.3 per cent of the total area under fruit crops of India occupies third position after banana and mango and about 10 per cent annual fruit production of the country. During last four decades, the area under citrus has increased from 90.7 thousand ha in 1961 to present acreage of 496.6 thousand ha in terms of area, and production increased from 823.7 thousand tones to 4399.5 thousands tones with an average productivity of 8.9 t ha (Anon, 2011).

The production of fruits can be increased by proper supply of nutrients in the form of fertilizer. Fertilizer is one of the major inputs accounting for nearly one third of the cost of cultivation and its production consumes a lot of energy used in horticulture. The conventional farming system involves enormous use of chemical in horticultural production. Continuous use of chemical fertilizers has degraded the soil health in terms of fertility and has also caused soil pollution. Organic manures have been used for their ecofriendly and beneficial effect on environment and horticultural crops. Organic manures are effective means for improving soil aggregation, structure and fertility, increasing microbial diversity and population, improving moisture holding capacity of soils, increasing the soil cation exchange capacity and consequently crop yields (Shrivastav and singh, 2003). Moreover, the significance of organic and biological resources as environment friendly, renewable sources of energy and low cost agro inputs have received much attention all over the world. The era of development in this field will ensure fairly high level of fruit production with sufficiently reduced dose of fertilizers and nutrients. Therefore, increasing need is being felt to integrate nutrient supply with organic sources to restore the health of soil.

The integrated nutrient management infuses long term sustainability in the productivity level because of availability of nutrients in soil for next season crop. Incorporation of organic fertilizers is a common practice to improve the yield of many fruit crops. It also limits chemical intervention and finally minimizes the negative impact on the wider environment.

It is the most appropriate approach for managing the nutrient input. It is the important alternative source, which is not only beneficial to maintain the soil health but also to sustain the fruit production. Application of organic manure combined with chemical fertilizer is associated with increased soil fertility and improved soil physical and chemical properties, thus it can increase crop production.

Integrated nutrient management improve crop growth and quality of products, help in sustainable crop production through maintenance of soil productivity. A lot of systematic work has been done on various aspects on nutrient management in fruit crops based on time, doses, methods and forms of fertilizer to be applied. However, it is varied with region soil conditions, variety, rootstock and crop load. Deficiency of essential nutrient element especially micro nutrients is wide spread and sometime lead to huge crop losses. These deficiencies are associated with poor fruit set, heavy fruit drop, and poor quality of produce and make the trees vulnerable to Disease and other disorders. Large scale use of chemical fertilizers causes problems of ground water and environmental pollution through leaching and volatilization. It has now been realized that use of chemical fertilizers must be integrated through more economic, renewable and environmental friendly organic manures and biofertilizers. Biofertilizers are not alternatives for inorganic fertilizer but they are helpful in improving soil and leaf nutrient status when they are used in combination with organic and inorganic nutrient sources.

Material and Methods

The experiment was conducted at Department of Horticulture Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2011-2012 and 2012-13. The experiment was laid out in Randomized Block Design (RBD) with nine treatments comprising of organic and inorganic manures which were replicated thrice. The details of experimental treatment were as,

The experiment was laid out in Randomized Block Design (RBD) with nine treatments comprising of organic and inorganic manures which were replicated thrice. The details of experimental treatment were as:

T1	(100% Rec. N, P and K (1200:400:400 g NPK/tree)-through Urea+ SSP+ MOP)
T2	(75% Rec. N (900 g N/tree) + 25 % N through FYM)
T3	(75% Rec. N (900 g N/tree) + 25 % N through Vermicompost)
T4	(75% Rec. N (900 g N/tree) + 25 % N through Neem cake)
T5	(75% Rec. N(900 g N/tree) + 25 % N through FYM + Bio-fertilizers (AM+PSB @ 100 g/tree)
T6	(75% Rec. N(900 g N/tree) + 25 % N through Vermicompost + Bio-fertilizers (AM+PSB @ 100 g/tree)
T7	(75% Rec. N (900 g N/tree) + 25 % N through Neem cake + Bio fertilizers (AM +PSB @ 100 g/tree)
T8	(100% Rec. N, P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @ 100 g/tree)
T9	(100% Rec. N, P&K(1200:400:400g NPK/tree) + 7.5 kg Neem cake

Recommended dose of FYM @ 50 kg/tree will be common to all treatments. Recommended dose of P and K @ 400 g/plant will be applied common to treatment T2 to T7. Nine-year-old healthy sweet orange plants of Nucellar variety of uniform growth were selected from the Sweet Orange orchard, Department of Horticulture for present experiment and the analytical work was done at Analytical Laboratory, University Department of Horticulture and Department of soil science Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

During investigation the observations were recorded regarding available nitrogen was determined by Kjeldhal's method (Piper 1966) [17]. Total phosphorus was determined by Vanadomolybdate yellow color method. Total potassium was determined by using flame photometer method (Piper 1966) [17]. Organic carbon was calculated by Walkely and Black method (Nelson and Sommer, 1982).

Results and Discussions

Days required for flowering to harvesting

The perusal data presented in Table 1, revealed that days required for flowering to harvesting was not influenced significantly by the different treatments of nutrient management.

During first season of experimentation treatment T_1 and T_5 took minimum days (239.33) from flowering to harvesting and treatment T_4 took maximum days (244.33). While during second season of experiment in treatment T_1 showed early harvesting (241.33) and T_3 treatment took maximum days (245.67).

Number of flower per shoot

The perusal data presented in Table 1, revealed that number of flower per shoot significantly influenced by organic and inorganic sources of nutrients. The maximum number of flowers (27.50) was found with application of 75%Rec.N (900 g N/tree) + 25 % N through Neem cake T_4 which is at par with all the treatment except T_2 and T_5 during the first season. However, in second year numbers of flowers (27.00) were recorded with application of 75%Rec.N (900 g N/tree) + 25 % N through vermicompost (T_3) which was at par with all the treatment except treatment T_2 and T_5. While, the minimum number of flower per shoot was recorded in treatment T_5 (19.00) in first year season and T_2 (19.17) in second season of experimentation.

This might be due to fact that in condition of surplus nutrition provide through organic manures, in organic fertilizers and bio-fertilizers the tree remains vegetative and functional hence, accumulation of carbohydrates induces flowering with adequate nutrition. The applied fertilizers and manures are helpful in maintaining a proper C: N ratio (CCC: NN) in shoots which is essential to produce flowers (kunte *et al.* 2005) [8]. The result of present findings are confirmed with the findings of Dheware and wag mare (2009) [3] in sweet orange, Pilania *et al.* (2010) [16] in guava.

Number of fruits per shoot

The perusal data presented in Table 1, revealed that number of fruits per shoot significantly influenced by the treatments of nutrient management. During the first season maximum number of fruits per shoot (7.83) were found in the treatment T_3 and T_7 (75%Rec.N (900 g N/tree) + 25 % N through Vermicompost and 75%Rec. N (900 g N/tree) + 25 % N through Neem cake + Bio fertilizers AM +PSB @ 100 g/tree) which was at par with all the treatment except T_1 (5.00). In the second maximum number of fruits per shoot (8.17) were recorded in T_7 (75%Rec. N (900 g N/tree) + 25 % N through

Neem cake + Bio fertilizers (AM +PSB @ 100 g/tree) which was at par with T_3 (7.67), T_4 (7.17) and T_8 (7.17). whereas, minimum number of fruits (5.00) and (5.83) were observed in the treatment T_1 and T_9 respectively.

From the Table 1, it is revealed that, the fruit set percent was significantly influenced with integration of organic, inorganic sources of nutrients along with bio-fertilizers in sweet orange. The maximum fruit set 41.02% was observed in treatment T_5 (75% Rec. N (900 g N/tree) + 25 % N through FYM + Bio-fertilizers AM+PSB @ 100 g/tree) per plant per year which was found at par with treatments T_3 (34.37) and T_7 (32.76) while minimum fruit set (20.61%) was recorded in treatment T_1 in first season. While, during second season maximum fruit set (33.83%) was recorded in treatment T_2 (75% Rec. N (900 g N/tree) + 25 % N through FYM /plant) which, was at par with all treatments except treatment T_9 and T_1. whereas, minimum fruit set was recorded in T_9 (23.44%).

The higher percentages of fruit set in present studies are might be due to the cumulative effect of organic manures and inorganic fertilizers along with bio-fertilizers. The results are agreement with the workers Dheware and Wag mare (2009) [3] in sweet orange Mahendra Singh *et al.* (2009) [9] in Ber, Hiwale *et al.* (2010) [5] in Sapota and Mitra *et al.* (2010) [11] in Guava.

Table 1: Flowering and fruiting influenced by combined use of organic, inorganic and biological sources

Treatment	Days required for Flowering to Harvesting (Days)		Number of Flowers Shoot^{-1}		Number of Fruits Shoot^{-1}		Fruit Set (%)	
	(2011-12)	(2012-13)	(2011-12)	(2012-13)	(2011-12)	(2012-13)	(2011-12)	(2012-13)
T_1	239.33	241.33	24.33	25.17	5.00	6.50	20.61	23.69
T_2	240.33	242.67	20.67	19.17	6.17	6.50	30.59	33.83
T_3	241.67	245.67	23.17	27.00	7.83	7.67	34.37	29.58
T_4	244.33	245.00	27.50	25.33	7.67	7.17	27.63	28.46
T_5	239.33	243.33	19.00	21.33	7.67	6.50	41.02	29.69
T_6	240.67	244.33	23.67	24.17	6.50	6.83	27.83	30.52
T_7	244.00	243.00	25.00	24.67	7.83	8.17	32.76	33.04
T_8	242.33	242.00	24.83	25.83	6.50	7.17	26.72	27.04
T_9	241.00	243.67	24.17	25.33	6.67	5.83	28.19	23.44
'F' test	NS	NS	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)±	1.87	1.33	1.55	1.28	0.57	0.40	3.04	2.09
CD at 5 %	-	-	4.63	3.83	1.71	1.20	9.12	6.27

Number of fruit per plant

The perusal data presented in Table 2, revealed that number of fruit per plant in sweet orange was significantly influenced by the integration through organic, inorganic and bio-fertilizer nutrient during both the season. The maximum number of fruits (225.50 and 225.17 fruit plant^{-1}) were recorded in treatment T_7 (75%Rec. N (900 g N/tree) + 25 % N through Neem cake + Bio fertilizers AM +PSB @ 100 g/tree per plant per year) respectively during first and second season of experiment. However minimum number of fruits (191.17) and (193.33) were recorded in treatment T_2 respectively during first and second season.

Increase in that number of fruit per plant might be due fact that use of inorganic fertilizers along with FYM, *PSB* which has direct role in production of phytohormone like substances and increased uptake of nitrogen. These results are in agreement with Goramnagar *et al.* (2000) [4] in Nagpur mandarin and Musmade *et al*. (2009) [12] in acid lime.

Fruit weight

The perusal data presented in Table 2, revealed that the average weight of sweet orange fruit was significantly influenced with combined application of organic, inorganic sources of nutrients along with bio-fertilizers. The maximum weight of fruit was recorded in T_4 (196.07g) (75%Rec.N (900 g N/tree) + 25 % N through Neem cake) which was found at par with T_5 (187.63g), T_8 (185.95g), T_7 (183.10g) and T_6 (183.83g) and T_9 (175.93g) during first year. While, minimum weight of fruit (152.97g) was recorded in treatment T_1. However during second season of experiment the maximum fruit weight (190.62 g) was found in the treatment T_6 (75%Rec.N (900 g N/tree) + 25 % N through Vermicompost + Bio-fertilizers (AM+PSB @ 100 g/tree) which was found at par with T_5 (189.48 g), T_7 (187.05 g) and T_9 (177.08 g). The minimum fruit weight was recorded in treatment T_3 (154.35g) during second season.

These results are in agreement with Ingle *et al.* (2001) [6] in mandarin and Patel *et al.* (2009) [13] in Sweet orange revealed that, the fruit weight was influenced significantly by application of organic and inorganic nutrients sources.

Fruit yield per plant

The perusal data presented in Table 2, revealed that, fruit yield per plant (Kg) in sweet orange was significantly influenced by the application different combinations of organic and inorganic sources of nutrients along with bio-fertilizers. The highest fruit yield (42.37 kg/plant) was recorded with the treatment of T_4 (75%Rec.N (900 g N/tree) + 25 % N through Neem cake per plant per year) which was found at par with treatment T_7 (41.28 kg/plant), T_6 (39.10 kg/plant), T_5 (38.04 kg/plant) and T_8 (37.92 kg/plant) during first season while, during second season of experimentation maximum fruit yield (42.03 kg/plant) was recorded in the treatment of T_7 (75%Rec. N (900 g N/tree) + 25 % N through Neem cake + Bio fertilizers (AM +PSB @ 100 g/tree) which was found at par with treatment T_4 (39.77 kg/plant) T_5 (37.42kg/plant), T_9 (38.63 kg/plant) and T_6 (39.21 kg/plant).

Increase in yield of fruits might be due fact that use of inorganic fertilizers along with FYM, *PSB* account of their direct role in phosphate fixation, production of phytohormone like substances and increased uptake of nitrogen. These results are in agreement with Goramnagar *et al.* (2000) [4] in Nagpur mandarin and Musmade *et al*. (2009) [12] in acid lime.

B: C Ratio

B:C ratio was work out considering prevailing market prices use for experimentation and considering the prices of fruits in local market.

The perusal data presented in Table 2, revealed that, Highest B: C ratio was recorded under treatment T8 (100%Rec.N, P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @ 100 g/tree) followed by treatment T4 (75%Rec.N (900 g

N/tree) + 25 % N through Neem cake) and T1 (100%Rec.N, P and K (1200:400:400 g NPK/tree)-through Urea+ SSP+ MOP) during first season. Similar trend was observed during second year, the highest B: C ratio was attributed the treatment T8 (100%Rec.N, P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @ 100 g/tree) were no organics were applied which resulted in lowering of cost ultimately reflected in higher B: C ratio.

Fruit Juice content

The perusal data presented in Table 2, revealed that fruit juice content of sweet orange fruits was significantly varied among the nine treatments from organic and inorganic sources of fertilizers. The maximum juice percentage 44.93% and 46.40% was recorded in T_4 (75%Rec.N (900 g N/tree) + 25 % N through Neem cake) during first and second season of the experimentation and which was found at par with all the treatment except T_1 which was recorded minimum during both the season i.e. 37.41 % and 40.86 % respectively.

Application of inorganic fertilizer along with bio-fertilizer resulted in an overall improvement in fruit quality and also reduction in dose of inorganic fertilizer. The results are close conformity with the Chokha Singh *et al.* (2000) [2] in mosambi, Patel *et al.* (2009) [13] in sweet orange and Marathe *et al.* (2012) [10] in sweet orange.

Table 2: Fruit yield as influenced by combined use of organic, inorganic and biological sources

Treatment	No. of fruits per plant		Fruit Weight (g)		Fruit yield (kg /plant)		B:C ratio	
	(2011-12)	(2011-12)	(2012-13)	(2012-13)	(2011-12)	(2012-13)	2011-12	2012-13
T_1	206.67	152.97	154.60	203.67	31.47	31.57	4.05	4.85
T_2	191.17	169.13	167.85	193.33	32.49	32.50	2.99	3.61
T_3	209.17	160.65	154.35	215.83	33.58	33.29	2.51	2.92
T_4	216.33	196.07	184.93	215.50	42.37	39.77	4.03	4.41
T_5	202.67	187.63	189.48	198.00	38.04	37.42	3.15	3.74
T_6	212.67	183.83	190.62	205.83	39.10	39.21	2.68	3.16
T_7	225.50	183.10	187.05	225.17	41.28	42.03	3.52	4.20
T_8	203.50	185.95	186.53	198.67	37.92	37.01	4.22	4.93
T_9	200.83	175.93	177.08	218.33	35.35	38.63	3.14	3.98
F' test	Sig	Sig	Sig	Sig	Sig	Sig	-	-
SE (m) +	6.02	7.99	6.11	6.65	1.96	1.66	-	-
CD at 5 %	18.06	23.94	18.33	19.94	5.87	4.99	-	-

Peel: pomace ratio

The data regarding peel: pomace ratio influenced by integrated nutrient management treatments and presented in Table 3 data presented that, maximum peel: pomace ratio was recorded in treatment T_5 (1.54 and 1.43) respectively during first and second season of experiment. While minimum ratio was recorded in T_8 i.e. (1.16 and 1.14) respectively.

Fruit chemical quality

The data regarding fruit quality in terms of total soluble solid, titratable acidity, ascorbic acid and Influenced by the application of combinations of organic, inorganic manures and bio-fertilizers was recorded and presented in Table 3.

Total soluble solids

The perusal data presented in Table 3, revealed that the TSS of sweet orange juice was significantly influenced by the different combinations of organic manures, inorganic fertilizers along with bio-fertilizers. It was observed that, during first season significantly maximum fruit juice TSS (9.20^0B) was recorded in treatment T_5 (75%Rec.N (900 g N/tree) + 25 % N through FYM + Bio-fertilizers (AM+PSB @ 100 g/tree) followed by T_8 (8.8^0B) and T_7 (8.47^0B) while minimum juice TSS was recorded in treatment T_9 (7.88^0B).

As regard second season maximum fruit juice TSS (9.28^0B) was found associated with treatment T5 (75%Rec.N (900 g N/tree) + 25 % N through FYM + Bio-fertilizers (AM+PSB @ 100 g/tree) which, was found at par with T_8 (9.08^0B), T_7 (8.75^0B).During second season, minimum TSS was recorded in treatment T_2 (8.18^0B).

The increased fruit quality might be explained from the fact these microbial fertilizers enhance the nutrient availability by enhancing the capability of plant to better solute uptake from rhizosphere. Results in close conformity with the findings of Chokha Singh et al. (2000) [2] Musmade *et al.* (2009) [12] in acid lime and Marathe *et al.* (2012) [10] in sweet orange.

Titratable acidity

The perusal data presented in Table 3, revealed that, titratable acidity of fruit juice of sweet orange was significantly influenced by combine application of organic manures, inorganic fertilizers along with bio-fertilizers. The minimum titratable acidity of fruit juice (0.25%) was recorded in treatment T_9 which at par with T6 (0.27%), T1 and T_7 (0.29%) and T_8 (0.35%) and maximum was recorded in treatment T5 (0.43%). While during second season of experiment minimum titratable acidity was recorded in treatment T_9 (0.31%) T_6 (0.28%) which was at par with T_5, T_7 (0.32%), T_1 (0.34%), T_3 (0.35%) and T_4 (0.36%) whereas, maximum titratable acidity was recorded in treatment T_8 (0.39%).

The results are close conformity with the findings of Ingle *et al.* (2001) [6], Patil and Hiwarale (2004) [14] in acid lime, Khan and Hameedunnisa-Begum (2007) in acid lime,

Ascorbic acid

The perusal data presented in Table 3, revealed that, ascorbic acid content in fruit juice of sweet orange was significantly influenced by integration of organic, inorganic sources of nutrients along with bio-fertilizers. It was observed that, maximum ascorbic acid content (22.42 mg/100 ml) observed in treatment T_8 (100%Rec.N, P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @ 100 g/tree) per plant per year) which was found at par with T_3 (21.38 mg/100 ml), T_9 (21.37 mg/100 ml), T_6 (20.50 mg/100 ml) T_7 (20.63 mg/100 ml) during first season. During second season of experiment maximum ascorbic acid (23.65 mg/100 ml) was observed in the same treatment T_8 (100%Rec.N, P&K (1200:400:400 g NPK/tree) + Bio fertilizers (AM+PSB @ 100 g/tree) per plant per year) which, was at par with T_5

(22.48 mg/100 ml), T_6 (22.20 mg/100 ml) and T_7 (22.02 mg/100ml). While, minimum ascorbic acid content in sweet orange juice (18.47 and 20 mg/100ml) was recorded during first and second season of experiment respectively in T_1.

The results also closely related with findings of Chokha Singh *et al.* (2000) [2] in mosambi, Patel *et al.* (2009) [13] in sweet orange, Pawar (2011) [15] in acid lime.

Table 3: Fruit Juice Content, Peel: Pomace ratio, Total Soluble Solids, titratable acidity and ascorbic acid content as influenced by combined use of organic, inorganic and biological sources

Treatment	Fruit Juice Content (%)		Peel: Pomace ratio		TSS (^{0}Brix)		Titratable acidity (%)		Ascorbic Acid (mg/100ml)	
	(2011-12)	(2012-13)	(2011-12)	(2012-13)	(2011-12)	(2012-13)	(2011-12)	(2012-13)	(2011-12)	(2012-13)
T_1	37.41	40.86	1.17	1.16	8.17	8.43	0.29	0.34	18.47	20.00
T_2	42.51	42.43	0.85	0.89	7.91	8.18	0.38	0.38	18.38	21.03
T_3	43.82	42.95	1.16	1.07	8.15	8.48	0.37	0.35	21.38	22.68
T_4	44.93	46.40	1.08	0.91	8.28	8.48	0.35	0.36	19.88	21.63
T_5	42.98	43.18	1.54	1.43	9.20	9.28	0.43	0.32	19.92	22.48
T_6	41.29	46.00	1.40	1.23	7.92	8.3	0.27	0.28	20.50	22.20
T_7	39.69	41.47	1.47	1.26	8.47	8.75	0.29	0.32	20.63	22.02
T_8	42.10	42.34	1.16	1.14	8.88	9.08	0.35	0.39	22.42	23.65
T_9	41.48	39.41	1.40	1.14	7.88	8.38	0.25	0.31	21.37	21.17
'F' test	Sig	Sig	--	--	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)±	1.35	1.40	--	--	0.03	0.21	0.03	0.02	0.83	0.65
CD at 5 %	4.05	4.19	-	-	0.10	0.65	0.10	0.06	2.48	1.95

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