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Effect of Different Inorganic, Organic and Bio-Fertilizers on Plant Growth of Sweet Orange (*Citrus sinensis* Osbeck.)

Johnson Lakra[1*], Muktilata Tirkey[2], Ravina Pawar[1] and Panma Yankit[1]

[1]Dr Y. S. Parmar University of Horticulture and Forestry Nauni, Solan-173230, H.P., India
[2]Department of Vegetable Science, IGKV, Raipur-492006, Chattisgarh, India

**Corresponding author*

A B S T R A C T

The present investigation entitled "Effect of different Inorganic, Organic and Bio-fertilizers on plant growth of Sweet Orange (*Citrus sinensis* Osbeck)" were carried out at experimental field, Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences Allahabad (Uttar Pradesh) during the year (2015-2016). The experiment was laid out in Randomized Block Design (RBD) with thirteen treatments and each replicated thrice. The treatment T_6 (20 kg/plant Farm Yard Manure, 10 g/plant PSB, 10 g/plant *Azosprillium*, Nitrogen 337 g/plant, Phosphorus 112 g/plant and Potash 75g/ plant was found to be the most suitable in terms of maximum plant height (119.87 cm), maximum number of leaves (400.90), maximum number of branches (29.83), maximum stem diameter (2.40 cm), maximum spread of canopy (75.62 cm^2), maximum Leaf area (32.46 cm^2), maximum length of inter-nodes (8.60 cm) and minimum incidence of disease percentage (1.10 %) followed by treatment T_{12} (20 kg/plant Farm Yard Manure, 10 g/plant PSB, 10 g/plant *Azosprillium*, Nitrogen 225 g/plant, Phosphorus 75 g/plant and Potash 50 g/plant, whereas the minimum parameters were found associated with (T_0) control. The nutrient status of soil like EC, Nitrogen, Phosphorous and Potassium were also higher with treatment T_6 and the maximum pH was recorded with (T_0) control. The results of the present study suggested that combination of Inorganic, Organic and Bio-fertilizers are responsible for increased growth of sweet orange.

Keywords

Sweet orange, FYM, PSB, Azosprillium, Soil nutrients

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Introduction

The Sweet orange (*Citrus sinensis* Osbeck) is the members of family Rutaceae sub-family *Aurantoideae* (Davies and Zalman, 2006) and a single genus contains the most important species, sweet orange, mandarin, lemon, lime, citrus, grape fruit and the shaddock. All these are excellent source of vitamin 'C' and fruit acids and are appreciated all over the world for their "fruity" fruit taste and refreshing qualities (Helail *et al.*, 2012). The citrus fruits contain no fat and cholesterol but many phytochemicals which are very good to reduce cardiovascular diseases (Fake, 2004). Among the several groups of citrus mandarin is the major followed by orange and lime. Sweet orange occupying an area of 191 lakh hac with a production of 32.09 lakh MT and a productivity of 16.7 MT/hac, Andhra Pradesh is leading in Sweet Orange production 17.52 lakh MT (NHB database, 2017). The management of nutrients through organic and biological sources would be more beneficial and eco-friendly to improve the health of soils and quality of fruit produce. The current trend is to explore the possibility of supplementing chemical fertilizers with organic fertilizers, especially bio-fertilizers of microbial origin Patil *et al.*, 2005. Continuous use of chemical fertilizers has reduced the soil fertility, productivity and has also caused soil pollution. The period of development in the field of combined nutrient management will ensure fairly high level of fruit production with sufficiently reduced dose of fertilizers and nutrients. In the present study, poor tree growth was noticed when one or more sources of nutrients were missing. This may be due to the reason that absence of even single source caused misbalancing in the nutrient uptake by the plants, hindering proper plant growth. Thus, the optimized standards of fertilizer application are of great importance to get good growth. Therefore, the present study were undertaken to find out the best possible combination of inorganic, organic and bio-fertilizers which can stimulate the citrus production without adversely affecting the quality of soils.

Materials and Methods

The field investigations were laid out on two years old "Mosambi" sweet orange plant which were planted at a distance of 5×5 m in an orchard of Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during the year 2015-16. The experimental design was complete randomized block design with thirteen treatments and each replicated thrice. The following as inadequate levels of Nitrogen (g/plant), Phosphorus (g/plant), Potassium (g/plant), FYM (kg/plant), *Azospirillium* (g/plant) and PSB (g/plant) like doses of fertilizers: T_0(N_0 P_0 K_0 FYM_0 $Azospirillum_0$ PSB_0, T_1(N_{337} P_{112} K_{75} FYM_{20}), T_2(N_{337} P_{112} K_{75} $Azospirillium_{10}$), T_3(N_{337} P_{112} K_{75} PSB_{10}), T_4(N_{337} P_{112} K_{75} FYM_{20} $Azospirillium_{10}$), T_5(N_{337} P_{112} K_{75} FYM_{20} PSB_{10}), T_6(N_{337} P_{112} K_{75} FYM_{20} $Azospirillium_{10}$ PSB_{10}), T_7(N_{225} P_{75} K_{50} FYM_{20}), T_8(N_{225} P_{75} K_{50} $Azospirillium_{10}$), T_9(N_{225} P_{75} K_{50} PSB_{10}), T_{10}(N_{225} P_{75} K_{50} FYM_{20} $Azospirillium_{10}$), T_{11}(N_{225} P_{75} K_{50} FYM_{20} $Azospirillium_{10}$) and T_{12}(N_{225} P_{75} K_{50} FYM_{20} $Azospirillium_{10}$ PSB_{10}), per plant was applied for all the treatments. The first doses of fertilizers were applied immediately after weeding (20^{th} October, 2016). Intercultural operations like weeding, irrigation, pruning, disease and insect management were done as per required. Data on growth characters were taken duly. Data were statistically analyzed using computer MSTATC program.

Results and Discussion

The application of organic sources of manure, biofertilizers and inorganic nutrient, affected vegetative growth. The maximum tree height increment was recorded in T_6 (20 kg FYM, 10 PSB, 10 g Azospirillium, Nitrogen 337 g, Phosphorus 112 g and Potash 75g / plant (119.87 cm) followed by T_{12}. These values were minimum with T_0 control. This might be due to improved nutritional status and physical properties of the soil caused by the addition of FYM. This made the plant to uptake water and mineral nutrients better, resulting in its increased growth rate. Similarly, significant growth of kinnow mandarin by the application of FYM has been earlier reported by Dudi *et al.,* (2003). The minimum tree height in control treatment (T_0) might be due to without application of nutrients and ultimately the supply of insufficient quantity of nutrients needed for the growth of the plant as also reported by Atom (2013) and Patel *et al.*, (2009).

The maximum Number of Leaves was recorded in same treatment T_6 followed by T_{12}. However, minimum Number of Leaves was recorded control.

The maximum number of leaves could be attributed to the easy availability of required quantity of nutrients and improved soil conditions due to the addition of organic and bio-fertilizer, while the lower values of these traits in control treatment could be attributed to non- availability of required quantum of nutrients The above results are in conformity with the findings of Kaul and Bhatnagar (2006) in Kinnow mandarin.

The branches per plant were highest in T_6. However, minimum Number of branches per plant was recorded control. This increase was might be due to the availability of major as well as minor nutrient elements at optimum proportion in the soil and assimilation of food material within the plant reported by Patel *et al.,* (2009), Marathe and Bharambe (2007) in sweet orange.

The maximum Stem diameter(cm) was recorded in T_6 may be due to the increase in shoot length and number of leaves which might have resulted to production of more quantum of carbohydrates and subsequently their translocations towards the stem.

These findings can be very well supported with the findings of Dheware and Waghmare (2009) and Patel *et al.,* (2009)

The plants maximum plant spread (cm^2) was recorded in T_6 followed by T_{12}. However, minimum plant spread was recorded control. The maximum plant spread may be due to the increase in shoot length and number of leaves which might have occurred due to higher nutrient availability supporting higher accumulation of photosynthesis in the plant body. While, the minimum values of tree spread in control treatment may be due to poor availability of nutrients.

The maximum Leaf area (cm^2) was recorded in T_6 followed by T_{12} and minimum Leaf area was recorded control.

It has been well documented that the beneficial effects of farmyard manure and bio-fertilizer along with inorganic fertilizers help in improving the soil health in terms of nutrient availability as well as by improving the soil physical and biological condition thereby, increasing the nutrient availability for the growth and developmental processes of the plant. The present findings are in accordance with the report of Sharma (2004).

The Length of Internodes was greater in same treatment T_6 because the combined application of organic, inorganic and bio-fertilizers is a result of the interaction to them which helped in increasing the soil nutrient availability and their uptake by the plants that resulted in better vegetative growth. These findings are in agreement with the findings of Dheware *et al.*, (2010).

The least incidence of disease percentage was same as in treatment T_6. However maximum Incidence of disease percentage was recorded control. Similar findings were reported by Singh and Sharma (2008) in Citrus Management (Yasin *et al.,* 2003; Zekri and Obereza, 2003) in citrus. Data in table 5 revealed that soil nutrient increased significantly with combined application of manure and fertilizer. The maximum increased of nitrogen, phosphorus and potassium was observed in treatment T_6 (Table 1–5)

Table.1 Vegetative growth of Sweet Orange plants as affected by different treatments

Treatments	Effect of Inorganic, Organic and Bio-fertilizers on Plant height (cm)					Effect of Inorganic, Organic and Bio-fertilizers on Number of leaves (cm)				
	30DAT	60DAT	90DAT	120DAT	150DAT	30DAT	60DAT	90DAT	120DAT	150DAT
T_0	54.02	57.38	60.1	63.11	66.03	215.49	223.55	232.68	242.14	248.27
T_1	78.55	81.61	84.66	87.81	90.25	269.84	281.98	294.46	303.1	319.62
T_2	72	74.38	76.52	79.37	83.08	263.25	274.82	282.71	293.42	308.63
T_3	70.49	72.19	75.43	78.8	81.71	257.92	265.01	278.06	289.4	300.75
T_4	91.5	95.2	98.48	102.67	106.26	323.2	331.72	349.71	359.76	369.53
T_5	89.62	92.78	94.89	99.9	104.03	327.48	335.33	347.74	359.38	368.15
T_6	104.15	109.24	113.99	116.29	119.87	363.84	373.12	380.93	391.02	400.9
T_7	72.26	75.05	79.47	82.52	87.01	283.99	290.93	300.7	309.26	316.56
T_8	68.58	70.57	74.61	77.73	79.79	235.15	241.99	254.27	260.61	269.77
T_9	60.76	65.63	69.59	73.23	76.31	222.07	230.79	241.03	252.21	260.95
T_{10}	86.36	89.67	93.08	95.69	101.49	290.84	306.55	317.61	329.33	337.2
T_{11}	82.66	85.63	87.87	91.39	94.5	293.51	304.4	314.42	325.03	337.46
T_{12}	95.28	98.55	100.69	105.58	108.67	342.22	352.57	363.03	372.79	383.06
F- test	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.917	0.949	0.881	0.849	0.860	1.386	1.376	1.394	1.426	1.444
C. D. at 5%	1.892	1.959	1.819	1.753	1.774	2.860	2.840	2.876	2.943	2.981

Table.2 Vegetative growth of sweet orange plants as affected by different treatments

Treatments	Effect of Inorganic, Organic and Bio-fertilizers on Number of branches per plant					Effect of Inorganic, Organic and Bio-fertilizers on Stem diameter (cm)				
	30DAT	60DAT	90DAT	120DAT	150DAT	30DAT	60DAT	90DAT	120DAT	150DAT
T_0	11.83	13.83	15.92	17.92	66.03	1.54	1.64	1.75	1.84	1.96
T_1	14.33	16.84	18.37	19.66	90.25	1.84	1.95	2.06	2.16	2.26
T_2	13.5	15.39	17.5	20.63	83.08	1.7	1.97	2.08	2.2	2.2
T_3	11.36	14.03	16.53	18.97	81.71	1.66	1.75	1.87	1.97	2.08
T_4	16.82	19.03	22	25.46	106.26	1.88	2.03	2.13	2.18	2.28
T_5	13.75	16.4	19.32	22.22	104.03	1.96	2.09	2.17	2.26	2.35
T_6	16.31	19.49	22.21	25.2	119.87	1.98	2.04	2.17	2.28	2.4
T_7	14	17.42	18.75	21.75	87.01	1.86	1.95	2.07	2.15	2.25
T_8	12.5	14.58	17	19.67	79.79	1.65	1.75	1.83	1.92	2.04
T_9	12.67	14.75	16.75	19.33	76.31	1.54	1.65	1.74	1.87	1.99
T_{10}	13.08	16.33	19.33	22.83	101.49	1.91	2.02	2.13	2.21	2.31
T_{11}	14.33	17.25	19.58	20.92	94.5	1.73	1.8	1.85	1.92	1.94
T_{12}	14.52	17.04	18.85	20.88	108.67	1.97	2.04	2.12	2.25	2.34
F- test	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.908	0.907	0.902	0.941	0.860	0.123	0.112	0.114	0.112	0.084
C. D. at 5%	1.874	1.871	1.863	1.942	1.774	0.254	0.230	0.235	0.230	0.174

Table.3 Vegetative growth of sweet orange plants as affected by different treatments

Treatments	Effect of Inorganic, Organic and Bio-fertilizers on Spread of canopy (cm^2)					Effect of Inorganic, Organic and Bio-fertilizers on Leaf area (cm)				
	30DAT	60DAT	90DAT	120DAT	150DAT	30DAT	60DAT	90DAT	120DAT	150DAT
T_0	34.97	36.51	38	39.39	40.97	40.97	20.88	21.56	22.47	24.98
T_1	44.48	45.61	46.37	47.58	50.17	50.17	24.4	25.15	26.03	27.02
T_2	37.78	39.25	41.23	42.65	44.26	44.26	24.02	24.5	25.27	26.07
T_3	36.9	37.87	38.97	40.9	41.82	41.82	21.87	22.73	23.74	25.14
T_4	59.88	60.34	62.84	64.34	66.43	66.43	28.25	28.74	29.68	29.32
T_5	53.28	56.16	58.37	60.26	62.44	62.44	27.64	28.35	29.5	29.83
T_6	66.16	68.03	70.19	72.25	75.62	75.62	29.51	30.33	30.72	31.73
T_7	40.74	42.78	44.25	47	48.26	48.26	23.69	24.68	25.47	26.55
T_8	62.65	63.47	65.4	66.71	38.63	38.63	21.61	22.43	23.3	24.67
T_9	31.33	32.06	33.75	35.58	36.46	36.46	27.51	28.33	29.12	30.55
T_{10}	49.98	52.46	54.33	56.64	58.06	58.06	26.95	27.53	28.49	29.65
T_{11}	48.67	50.55	52.53	54.17	56.25	56.25	26.43	27.43	28.39	28.88
T_{12}	64.22	66.93	68.88	71.21	73.06	73.06	28.87	28.82	29.91	31.2
F- test	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.493	0.463	0.394	0.456	0.389	0.389	0.856	0.869	0.887	0.802
C. D. at 5%	1.018	0.956	0.814	0.942	0.804	0.804	1.767	1.793	1.832	1.655

Table.4 Vegetative growth of sweet orange plants as affected by different treatments

Treatments	Effect of Inorganic, Organic and Bio-fertilizers on Length of internodes (cm)				
	30DAT	60DAT	90DAT	120DAT	150DAT
T_0	5.1	5.44	5.9	6.36	6.89
T_1	5.99	6.31	6.89	7.2	7.73
T_2	5.27	5.91	6.32	6.92	7.38
T_3	5.56	5.95	6.22	6.89	7.32
T_4	6.1	6.57	7.11	7.88	8.08
T_5	5.77	6.13	6.45	6.88	7.1
T_6	6.83	7.21	7.78	8.13	8.6
T_7	5.16	5.58	6.01	6.34	7.7
T_8	5.51	5.91	6.32	6.89	7.29
T_9	5.25	5.61	6.13	6.6	7.14
T_{10}	5.94	6.37	6.86	6.61	7.85
T_{11}	6.14	6.41	6.92	7.28	7.82
T_{12}	6.59	6.95	7.31	7.81	8.19
F- test	S	S	S	S	S
S. Ed. (±)	0.040	0.024	0.015	0.132	0.014
C. D. at 5%	0.082	0.049	0.031	0.273	0.028

Table.5 Soil nutrients of experimental field affected by different treatments

Treatment	pH	EC (dS m^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Initial	7.23	0.28	206.77	22.91	229.03
T_0	7.23	0.28	206.77	22.91	229.03
T_1	6.89	0.32	209.52	24.73	234.53
T_2	6.93	0.32	211.55	26.77	233.21
T_3	6.94	0.32	220.83	29.12	231.70
T_4	6.37	0.35	219.54	30.78	253.70
T_5	6.43	0.34	210.20	27.05	254.13
T_6	6.26	0.37	236.70	33.52	262.80
T_7	6.73	0.31	215.62	25.47	232.53
T_8	7.10	0.29	207.74	25.24	231.94
T_9	7.13	0.28	218.21	25.37	231.95
T_{10}	6.53	0.34	209.47	26.03	246.36
T_{11}	6.53	0.32	218.31	28.24	246.18
T_{12}	6.32	0.35	218.43	30.57	261.52
F- test	S	S	S	S	S
S. Ed. (±)	0.019	0.006	0.997	0.633	1.315
C. D. at 5%	0.040	0.013	2.058	1.306	2.714

Regarding this experiment of all parameters results showed significant variations under different treatments. So, treatment T6 recommended to be followed in sweet orange cultivation for better growth and development. However, the finding of this investigation needs to be further confirmed by long term studies for sustainable fruit production in *Citrus* species.

On the basis of results obtained, It is concluded that the treatment T_6 (20 kg/plant Farm Yard Manure, 10 g/plant PSB, 10 g/plant Azospirillium, Nitrogen 337 g/plant, Phosphorus 112 g/plant and Potash 75g/ plant) was found to be the most suitable and effective treatment combination in terms of plant height, number of leaves, number of branches, stem diameter, spread of canopy, leaf area, length of inter-nodes, minimum incidence of disease percentage and nutrient status of soil like EC, nitrogen, phosphorus and potassium were also higher with treatment T_6 and the maximum pH was recorded with T_0 (control).

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