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Research Article

Effect of Plant Growth Regulators and Micronutrients on Growth and Yield of Sweet Orange (*Citrus sinensis* L. Osbeck) cv. Mosambi

Shraddha Neware[1], Indira Yadav[2]* and Bharat Meena[3]

[1]Department of Fruit Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, 413 722, District Ahmednagar, Maharashtra, INDIA
[2]Department of Fruit Science, College of Horticulture and Forestry (Agriculture University, Kota) Jhalarapatan, Jhalawar-326 023 Rajasthan, INDIA
[3]Department of Vegetable Science, College of Horticulture and Forestry (Agriculture University, Kota) Jhalarapatan, Jhalawar-326 023 Rajasthan, INDIA

Abstract

An experiment was conducted to study the effect of different plant growth regulators and micronutrient on growth and yield of sweet orange cv. Mosambi at the orchard of Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India during 2014. It involved 13 treatments in randomized block design. Application of T_4 {2, 4-D (20 ppm) + ZnSO4(1%) + $FeSO_4$ (1%) + $MnSO_4$ (1%)} was found to be more effective in increasing number of fruits per tree, average fruit weight and yield. However, the application of T_8{GA_3 (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %)} was found to be more effective in increasing plant height, canopy volume and total chlorophyll content of leaves than control (T_{13}). The minimum number of seeds/fruit was found in treatment T_6{GA_3 (10 ppm) + ZnSO4 (1%) + FeSO4 (1%) + MnSO4 (1%)}. It proved the effectiveness of micronutrient and growth regulators in increasing growth and yield of sweet orange.

Keywords: Citrus sinensis L., Micronutrients, Growth regulators, Growth, Yield

***Correspondence**
Author:Indira Yadav
Email:indirayadav999@gmail.com

Introduction

Growth regulators controlling the sizecolor and premature fruit drop. Citrus trees produce profuse flowers which develop into fruits that are later shed off necessarily to reduce heavy fruit load, so that the fruits remaining on the tree can be sustained. As the fruit size in early stage is very small, the dropping is minimal. However, it is very severe when fruits are of medium size and whole area under citrus is covered with dropped fruits [1]. Similarly, deficiency of micronutrients (Zn, Cu, Fe, and Mn) in the soil of citrus orchards also affects the fruit yield and quality [2, 3]. Zinc deficiency is considered to be the most widespread and damaging micronutrient deficiency of citrus. However, foliar application of Zn can improve the citrus fruit yield and quality and control the premature fruit drop [4]. Different workers suggested that application of suitable combination of plant growth regulators, macro and micro-nutrients can control the excessive fruit drop and improve the yield and quality of citrus fruit [5]. Therefore, effective supply of nutrients (macro and micro) and plant growth regulators is necessary to produce high yield with quality citrus fruits. Hence present investigation employing plant growth regulators and micronutrients in sweet orange was undertaken with an objective to find out effect on yield and quality in sweet orange under agro-climatic conditions existing at Rahuri.

Materials and Methods

Experimental site

A field experiment entitled effect of plant growth regulators and micronutrients on sweet orange was carried out in the Ambia bahar of year 2014 at the orchard of Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmednagar, Maharashtra.

Experimental design and treatments

The experiment was laid out in randomized block design with 13 treatments, viz. T_1- 2,4-D (10 ppm) + ZnSO4 (0.5 %) + FeSO4 (0.5 %) + MnSO4 (0.5 %),T2- 2,4-D (10 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) +MnSO4 (1 %), T3- 2,4-D (20 ppm) + ZnSO4 (0.5 %) + FeSO4 (0.5 %) + MnSO4 (0.5 %), T4- 2,4-D (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) +MnSO4 (1 %), T5- GA3 (10 ppm) + ZnSO4 (0.5 %) + FeSO4 (0.5 %) + MnSO4 (0.5 %), T6- GA3 (10 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %), T7- GA3 (20 ppm) + ZnSO4 (0.5 %) + FeSO4 (0.5 %) + MnSO4 (0.5 %), T8- GA3 (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) +MnSO4 (1 %), T9- NAA (50 ppm) + ZnSO4 (0.5 %) + FeSO4 (0.5 %) + MnSO4 (0.5 %), T10- NAA (50 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1%), T11-NAA (100 ppm) + ZnSO4 (0.5 %) + FeSO4 (0.5 %) + MnSO4 (0.5 %), T12- NAA (100 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) +MnSO4 (1 %), T13-Control with two replications.The growth regulators and micronutrients were sprayed at two times. First spraying of plant growth regulators and micronutrients was carried at petal fall stage in the second week of March and second spraying 45 days after first spray separately in the last week of April, 2014. Spraying was done as per the treatment early in the morning. Each tree was sprayed heavily by taking care to wet the complete tree. It was fully ensured that all the sides of the tree were quenched completely by the spraying solutions.

Crop management

A fertilizer dose of 20 kg farmyard manure + 15 kg neem cake and 800g N: 300g P2O5: 600 g K2O per tree was applied in the form of urea, single superphosphate and muriate of potash in two N split doses. First half dose of nitrogen along with full doses of P2O5, K2O and FYM + 15 kg neem cake was applied in second irrigation after stress in January and second half dose of nitrogen was applied at 45 days after first dose near the feeding root zone of the tree and mixed thoroughly with the soil.

Plant sampling and laboratory procedures

The observations include growth parameters viz. plant height, canopy volume were taken with help of measuring scale. Total chlorophyll content of leaves was taken using by the span type chlorophyll meter (Make: At leaf, USA and Model: PN 0131) for the chlorophyll content of sweet orange leaves samples.; yield parameters (Number of fruits per tree, Fruit weight and Fruit yield) are taken by harvesting fruits at once and number of fruits per plant was recorded and weigh are taken on electronic balance; physicochemical composition of fruit such as number of seed per fruit are also taken. All data were subjected to statistical analysis as per methods advocated by [6].

Results and Discussion

The results of the effect of different plant growth regulators and micronutrient on different characters are presented in **Table 1** and **2**. Significant differences were recorded among the treatments for all the characters. The character wise result has been discussed below.

Plant height

Application of GA_3 (20ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + $MnSO_4$ (1 %) (T8) resulted in higher increase in plant height as compared to other treatments. This might be due to GA3 which enhance cell elongation [6, 7]. The combine application of GA3 and micronutrients the plant height was increased. This maximum increase in growth parameters might be due to the favorable influence of applied micronutrients (zinc + manganese + iron) on vegetative characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic process of plants. Zinc is essential component of enzymes responsible for nitrogen metabolism, thereby resulting into increase in uptake of nitrogen by the plant. Further, involvement of Zn in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis, consequently it increased tissue growth and development. It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis [8]. Iron plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochrome, which participate in different functions in the plant metabolism [9, 10]. These results are on similar lines as that of previous findings of [11-15].

Table 1 Effect of plant growth regulators and micronutrients on plant height, canopy volumr and chlorophyll content of leaves in sweet orange

Sr. No.	Treatment details	Plant height (m)	Canopy volume (m^3)	Chlorophyll in leaf (%)
T_1	2,4-D (10 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %)+ $MnSO_4$ (0.5 %)	3.35	25.54	80.63
T_2	2,4-D (10 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	3.63	23.75	82.65
T_3	2,4-D (20 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %) + $MnSO_4$ (0.5 %)	3.61	23.87	79.65
T_4	2,4-D (20 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	3.55	25.62	82.40
T_5	GA_3 (10 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %)+ $MnSO_4$ (0.5 %)	3.63	24.00	83.70
T_6	GA_3 (10 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	3.45	21.07	85.95
T_7	GA_3 (20 ppm) + $ZnSO_4$ (0.5 %) + $FeSO_4$ (0.5 %) + $MnSO_4$ (0.5 %)	3.50	26.06	82.70
T_8	GA_3 (20 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	3.85	20.85	93.55
T_9	NAA (50 ppm) + $ZnSO_4$ (0.5 %) + $FeSO_4$ (0.5 %)+ $MnSO_4$ (0.5 %)	3.70	24.54	78.95
T_{10}	NAA (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	3.60	24.25	83.20
T_{11}	NAA (100 ppm) + $ZnSO_4$ (0.5 %) + $FeSO_4$ (0.5 %) + $MnSO_4$ (0.5 %)	3.35	22.70	84.40
T_{12}	NAA (100 ppm) + $ZnSO_4$ (1 %) + FeSO4(1 %)+ $MnSO_4$ (1 %)	3.48	25.26	84.75
T_{13}	Control	3.64	23.33	77.30
	S.E.m ±	0.17	1.14	2.42
	C.D. at 5 %	NS	NS	7.47

Table 2 Effect of plant growth regulators and micronutrients on number of fruits per tree, yield per tree, yield per hectare, fruit weight and number of seeds per fruit in sweet orange

Sr. No.	Treatment details	Number of fruits /tree	Yield (kg/tree)	Yield (t/ha)	Fruit weight (g)	Number of seeds/fruit
T_1	2,4-D (10 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %)+ $MnSO_4$ (0.5 %)	302.00	60.40	16.73	200.00	24.00
T_2	2,4-D (10 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	306.00	63.34	17.55	206.00	24.00
T_3	2,4-D (20 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %) + $MnSO_4$ (0.5 %)	306.50	62.22	17.23	203.00	19.00
T_4	2,4-D (20 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	307.66	63.38	17.56	207.00	22.50
T_5	GA_3 (10 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %)+ $MnSO_4$ (0.5 %)	285.50	52.02	14.41	182.20	17.50
T_6	GA_3 (10 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	288.00	53.28	14.76	185.00	17.00
T_7	GA_3 (20 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %) + $MnSO_4$ (0.5 %)	279.00	52.73	14.61	189.00	22.00
T_8	GA_3 (20 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	294.93	58.99	16.34	200.00	22.00
T_9	NAA (50 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %)+ $MnSO_4$ (0.5 %)	280.50	54.42	15.07	194.00	21.50
T_{10}	NAA (50 ppm) + ZnSO4 (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %)	299.50	60.20	16.68	201.00	22.00
T_{11}	NAA (100 ppm) + ZnSO4(0.5 %) + $FeSO_4$ (0.5 %) + $MnSO_4$ (0.5 %)	300.00	60.90	16.87	203.00	22.50
T_{12}	NAA (100 ppm) + ZnSO4 (1 %) + FeSO4(1 %)+ $MnSO_4$(1 %)	305.00	61.00	16.90	200.00	24.00
T_{13}	Control	265.00	47.24	13.08	178.25	24.50
	S.E.m ±	7.57	3.20	0.88	11.31	1.03
	C.D. at 5 %	23.32	9.87	2.73	NS	3.19

Canopy volume

Application of GA3 (20ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) resulted in higher increase in canopy volume as compared to other treatments. This might be due to the reason that GA3 and micronutrients increased uptake of water and nutrients due to persuasive swelling forces leading the softening of cell wall and thereby favoured better development of plants resulting in greater height and number of branches per plant and ultimately the greater plant spread and canopy volume. These results are on similar lines as that of [16, 17]who observed maximum increase in East-West canopy spread and North-South canopy spread with the foliar application of ZnSO4 (0.5 %) + FeSO4 (0.5 %) and GA3 (50ppm) in acid lime. Similar results were in close agreement with [1, 13, 18-20].

Total chlorophyll content of leaves

The maximum total chlorophyll content in leaves of sweet orange was recorded in T_8, GA3 (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) (93.55%). This may be due to GA3 which delay senescent pigment changes and oppose the ethylene induced loss of chlorophyll. GA3 increases concentration of N and Mg which are constituents of chlorophyll that's why total chlorophyll has been increased. Iron also plays a highly important role in plant chlorophyll synthesis and numerous enzyme systems.These results are in line with [21] who noticed that, exogenous application of GA3 (100 ppm) increae chlorophyll content in leaves. [22]

Number of fruits per tree

It was observed that the plant growth regulators and micronutrients application significantly influenced the fruit number per tree in sweet orange. The data revealed that, the treatment T4, 2,4-D (20 ppm) + ZnSO4 (1%) + FeSO4 (1%) + MnSO4 (1%) recorded the highest number of fruit per tree (307.66 fruits/tree). The minimum number of fruits (265.00) was recorded in control. Zinc assists the translocation of metabolites from source to sink, which leads to retention of more number of fruits on tree. The combined application of 2,4-D along with zinc, iron and manganese significantly increased number of fruits and yield. Zinc being the nutrient responsible for auxin synthesis, might have influenced the higher fruit retention and increased the number of fruits per tree. These results are in line with [23].

Fruit weight (g)

No significant differences among treatments were observed due to plant growth regulators and micronutrients. Though the results were non-significant the maximum fruit weight (207.00 g) was observed in treatment T4, 2,4-D (20 ppm) + ZnSO4 (1%) + FeSO4 (1%) + MnSO4 (1%) and minimum average fruit weight (178.25 g) was recorded in the control (T13). The increase in fruit weight due to application of 2,4-D might be due to the fact that 2,4-D might have raised the auxin level in the fruits, which ultimately helped in the development of fruits as there is a direct correlation between the auxin content and fruit growth in several crops. The increase in fruit weight with zinc sprays might be due to important component for fruit growth and development which have been influenced via tryptophan by zinc sprays. The improvement occurred in fruit quality and quantity due to supplying trees with zinc could be attributed to its effect on enhancing formation and translocation of carbohydrates and carbohydrate enzymes [24].

Yield (kg/tree)

The application of plant growth regulators and micronutrients significantly increased the fruit yield. Among the different treatments T4, 2,4-D (20 ppm) + ZnSO4 (1%) + FeSO4 (1%) + MnSO4 (1%) recorded the maximum yield (63.38 kg/tree). The control (T13) had recorded minimum yield (47.24 kg/tree).

The cumulative effect of 2,4-D along with zinc, iron and manganese increased the yield per tree than control. Increase in the yield due to application of micronutrients might be due to reduction in fruit drop, increase in fruit retention, number of fruits and average weight of fruits. These results are on similar lines with the findings of [25, 26] who recorded maximum yield in sweet orange by combined application of ZnSO4 and FeSO4 [11, 23, 27].

Yield (t/ha)

The plant growth regulators and micronutrients significantly increased the yield. Among the treatments the treatment

T4: 2, 4-D (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) recorded maximum yield (17.56 t/ha). Minimum yield (13.08 t/ha) was recorded in control (T13). As by application of PGRs and micronutrients T4: 2, 4-D (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) yield/tree is increases which ultimately increase yield in terms of tonne/hactere [25, 28, 29].

Number of seeds per fruit

Among the various plant growth regulators and micronutrients treatments, the minimum number of seeds per fruit (17.00 seeds/fruit) was recorded in T6, GA3 (10 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) treatment. However, the maximum number of seeds per fruit (24.50 seeds/fruit) was recorded in control.Previously it has been reported that sometime in seedy citrus cultivars seeds number is reduced by spray of GA_3; however it is cultivar dependent [1].

The present results are in consonance with the findings of researchers [12, 20] in orangewho reported that 200 mg L-1 GA_3 spray application one month after anthesis reduced the fruit size and seed number per fruit.

Conclusion

Thus the results of this study suggested that growth regulators and micronutrients have a great potential to affect plant growth and yield of sweet orange. Treatment GA_3 (20ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) was found best for growth parameters and 2, 4-D (20 ppm) + ZnSO4 (1 %) + FeSO4 (1 %) + MnSO4 (1 %) was observed best for yield and yield attributes. Therefore, these can be utilized for sustainable and ecological fruit production and the use of chemical fertilizers can be reduced to a great extent.

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