

Original Research Article

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Impact of Foliar Application of Growth Regulators and Macro Nutrients on Fruit Yield and Quality of Sweet Orange cv. Sathgudi

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ABSTRACT

Sathgudi cultivar of sweet orange is very popular in Andhra Pradesh and it is successfully grown in Rayalaseema region (Red and loamy soils) of Andhra Pradesh. In certain scarce rainfall regions of Andhra Pradesh, *Ambe bahar* flower initiation in sweet orange occurs late in February and extended up to first fortnight of March resulting poor fruit growth, leading to low economic fruit yields. To enhance the fruit growth and yields rapidly, an investigation was made in farmers orchard at two locations in YSR District with combined spays of growth regulators and macronutrients, consisting of 9 treatments viz., 2,4-dichlorophenoxy acetic acid (2,4-D) and GA₃ at 10ppm combined with two different concentrations of urea and monopotassium phosphate at 1 and 1.5 % and water spray (control) at different stages of fruit development. Two consecutive years (2017-18 and 2018-19) of study indicated that pre harvest spray of urea @ 1.5 % along with 2,4-D 10 ppm or GA₃ 10 ppm, one month before harvest enhances sweet orange fruit yield by 40 % and 39.76% respectively, as compared to control. The fruit weight was significantly improved due to application of plant growth regulators but not the fruit quality like TSS and acidity.

Keywords

Sathgudi, Plant growth regulators, Macronutrients, Fruit yield

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Introduction

In India, the important citrus fruits grown are mandarins, sweet oranges and acid lime sharing 40.60 per cent, 26.00 per cent and 25.10 per cent, respectively of total citrus fruit production in country. Andhra Pradesh ranks first in area (82.89 thousand ha) and

production (2003.10 thousand MT) whereas, Maharashtra ranks second in area (55.20 thousand ha) and production (684.80 thousand MT) (Anony., 2018). Sweet orange (*Citrus sinensis* L. Osbeck) is predominantly grown in sub-tropical areas of India. Flower formation in Citrus species is promoted either by drought or low temperature, followed by

restoration of climatic conditions favourable for growth in tropical and sub tropical conditions.

Citrus trees produce a very large number of flowers, 30-150 times more than they can bear the fruits (Huchche *et al.*, 2012). In Andhra Pradesh, sweet orange tends to bear heavily under optimum conditions during winter (*Ambe Bahar*: December - January) required for flowering resulting in very light crops or no crop in the next season (*Mrig and Hasta bahar*). This is because of the heavy load of fruits in the regular bearing season resulting in the exhaustion of the trees. With the changing climate scenario and delayed harvests in the sweet orange, it was noticed that *Ambe bahar* flower initiation occurs in late February and extended up to first fortnight of March. This leads to poor fruit set and small fruit size due to water stress, malnutrition and also hormonal imbalance.

Adequate nutrition of a plant helps to improve the optimum productivity and quality of the produce (Srivastava and Singh, 2002). Among nutrients, potassium is one of the most important macro-nutrients which highly mobile in plants from individual cell to xylem and phloem transport. Potassium (K) improves fruit quality by enhancing fruit size, juice content, color, size and juice flavor (Ashraf *et al.*, 2010). Flowering, fruit set and its retention depend on several factors and hormonal regulation is one of them. Auxins and gibberellins can be used to control the fruit drop and improve the fruit quality in citrus (Almeida *et al.*, 2004) and also foliar spray of 2, 4 - D at 10 ppm and GA3 at 25 ppm to control fruit drop in mosambi sweet orange under rainfed condition (Ghosh *et al.*, 1995). The foliar application of GA3 may help in increase yield by reducing the percent fruit drop in sweet orange (Ullah *et al.*, 2014) and also highest fruit weight and fruit size, length were recorded with foliar application

of GA3 30 ppm in sweet orange cv. Jaffa (Sweety *et al.*, 2018). Researchers have suggested that application of suitable plant growth regulators and nutrients (macro and micro) for the control of excessive fruit drop and improvement of the yield plus quality of citrus fruits (Doberman and Fairhurst, 2000; Saleem *et al.*, 2005).

It is also necessary to control fruit drop and to enhance the fruit growth in sweet orange by supplementing the developing fruit with combined application of growth regulators and macronutrients as the endogenous hormones and their balance play a modulating role in the mobilization of nutrients to the developing organs. During field surveys of Citrus Research Station, Dr.YSRHU, Tirupati, Andhra Pradesh, from 2012-16, it was noticed that the highest intensity of dropping (45 to 50%) was in the month of April (one month after fruit set) followed by August (pre-harvest drop) which may be due to climatic condition of the region. Hence the present studies were planned to investigate the effect of exogenous applications of 2, 4-D and GA3 along with nitrogen and potassium nutrients at two different stages of fruit growth and development *i.e.*, one month after fruit set and one month before harvest.

Materials and Methods

The investigation was carried out for two seasons 2017 and 2018 for *Ambe Babar* crops in farmers field at Venkata Reddipalli and R. Rachapalli, YSR District, Andhra Pradesh on 8 year-old Sathgudi sweet orange (*Citrus sinensis* (L.) Osbeck) plants, budded on Rangpur lime root stock (*Citrus limonia*, L.), The trees are planted 6 × 6 meters apart. All trees are irrigated using drip irrigation system. The chosen trees for the experimentation were similar in vigor and subjected to the same horticultural practices (drip irrigation, fertilization, weeds & pest control) adopted in

the region according to the recommendation of YSRHU, Andhra Pradesh. The experiment was laid out in a randomized block design having three replications with two plants in each.

There were nine treatments *viz.*, T1: Monopotassium phosphate @1 % & 2,4-D10 ppm one month after fruit set, T2:Urea @1 % & 2,4-D @10 ppm one month after fruit set, T3:Monopotassium phosphate @1 % & GA₃10 ppm one month after fruit set, T4: Urea @1% & GA₃ @10 ppm one month after fruit set, T5: Monopotassium phosphate @1.5 % + 2,4-D 10 ppm one month before harvest, T6: Urea @ 1.5 % & 2,4-D @10 ppm one month before harvest, T7: Monopotassium phosphate@ 1.5 % & GA₃ 10 ppm one month before harvest, T8: Urea @1.5 % & GA₃ 10 ppm one month before harvest, T9:Control (water spray). Sweet orange trees were sprayed with the bio-regulator and macro nutrient solution at low concentrations, one month after fruit set (April) in first four treatments (T1 to T4) and high concentrations of pre-harvest sprays (August) were practiced in remaining four treatments (T5 to T8) at both the locations. Sticker (APSA-80) was used in the spray solution and spraying was done after sun set every time.

Number of fruits per tree was recorded at maturity in every year. Fruit weight was taken from 10 randomly selected fruits from each treatment and mean was calculated and expressed in grams. The fruit juice was expressed as weight of juice out of the total fruit weight in percent (%). The total soluble solids (TSS) of the sweet orange fruit juice was recorded by using hand refractometer (Erma, Japan) having range of 0-32 °Brix. The titratable acidity was estimated by titrating juice with 0.1 N NaOH by using the method as suggested by A.O.A.C. (1990). Fruit yield and quality parameters were recorded in both the years at two locations

and the pooled data was presented. The statistical analysis of the data generated during the course of study was analyzed as per the method suggested by Panse and Sukhatme (1967).

The climate is tropical with monthly maximum temperature of 40°C during summer season, minimum temperature of 15.65°C during winter season. The soil of the orchards selected is a red sandy loam with a pH of 7.2-7.8 and electrical conductivity of 0.43 dSm⁻¹. Soil contains 0.41 per cent, 158 kg ha⁻¹, 7.8 kg ha⁻¹, and 381 kg ha⁻¹ of organic carbon, available Nitrogen, phosphorus and potassium contents, respectively. Rainfall occurs mainly during northeast monsoon followed by southwest monsoon. Annual mean rain fall of 617 mm rainfall was recorded during the investigation period (Table 1).

Results and Discussion

Fruit yield

The results showed that the high concentration of bio- regulator and macro nutrient gave an increase in all fruiting parameters better than the low concentrations and control. The highest mean values of fruit number, fruit weight (g), and fruit yield (kg/tree) were obtained by application of Urea @1.5 % and 2,4-D 10 ppm one month before harvest (T6) and this treatment was at par with foliar spray of Urea 1.5 % and GA₃ 10 ppm one month before harvest (T8) during both 2017 and 2018 years, respectively. Highest fruit number with these treatments was because of minimum fruit drop. Significantly increase in fruit weight and yield due to application of 2, 4-D and GA₃ might be described to its positive action on enhancing both cell division and cell elongation as well as its great role in activating the biosynthesis of proteins, RNA

and DNA (Nickell, 1985). According to Kaur *et al.*, (2000) fruit weight increased with increase in amount of 2,4-D in trees of Kinnow mandarin and also in mosambi sweet orange (Ghosh *et al.*, 2012). The increase in fruit size could be attributed directly to exogenous application of 24-D acts as early and rapid on cell division in the fruitlet and also on subsequent growth. Thus, the fruit becomes bigger in size due to the increased cells, which are able attract so much water, minerals and carbohydrates that enable the

fruit to expand to large size. Also, gibberellins are known for their ability to increase cell enlargement, thus enhancing fruit growth in certain species such as citrus (Eman *et al.*, 2007, El- Sese 2005). The present results are in harmony with those obtained by Kassem *et al.*, (2012), who found that the foliar sprays of Washington navel oranges with GA3 @ 10 ppm at pre-harvest increase fruit size. On the other hand, the lowest fruiting parameters were obtained from control during the two seasons (Table 2).

Table.1 Rain fall pattern in farmers field

Month	Rain fall pattern in farmers field				
	2017	2018	Mean (mm)	Normal (mm)	Deviation (mm)
January	32.00	0.00	16.00	3.00	13.00
February	0.00	3.00	1.50	5.00	-3.50
March	4.00	25.40	14.70	10.00	4.70
April	0.00	0.00	0.00	5.00	-5.00
May	35.20	103.20	69.20	44.00	25.20
June	59.60	20.10	39.85	70.00	-30.15
July	45.80	5.00	25.40	72.00	-46.60
August	235.80	33.80	134.80	94.00	40.80
September	58.00	100.00	79.00	83.00	-4.00
October	185.70	10.00	97.85	147.00	-49.15
November	138.70	122.50	130.6	179.00	-48.40
December	8.20	8.00	8.10	50.00	-41.90
Total	803.00	431.00	617.00	762.00	-145

Table.2 Effect of different bio regulators on fruit yield of sweet orange

Treatments	Fruit no./tree			Fruit weight (g)			Yield (kg/tree)			Yield (t/ha)		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
T1	154.84	160.00	157.42	112.90	112.17	112.53	17.28	18.03	17.65	4.79	5.00	4.89
T2	162.50	167.17	164.83	126.98	131.25	129.12	19.48	20.80	20.14	5.40	5.76	5.58
T3	163.84	160.50	162.17	117.42	123.35	120.38	19.60	20.31	19.96	5.43	5.62	5.52
T4	183.00	160.84	171.92	127.57	128.50	128.03	23.54	21.09	22.31	6.52	5.84	6.18
T5	188.00	156.00	172.00	127.82	126.92	127.37	24.03	19.76	21.89	6.66	5.48	6.07
T6	187.17	189.00	188.08	134.42	120.35	127.38	25.95	22.91	24.43	7.19	6.35	6.77
T7	172.34	172.17	172.25	115.32	114.59	114.95	20.01	19.98	19.99	5.54	5.54	5.54
T8	186.17	184.50	185.33	129.24	133.84	131.54	23.93	24.74	24.34	6.63	6.85	6.74
T9(Control)	145.50	132.67	139.08	102.52	111.79	107.15	14.69	14.60	14.64	4.07	4.05	4.06
C.D@5%	19.42	16.51	18.39	8.73	19.63	NS	2.93	4.14	4.02	0.81	1.15	1.12
C.V.	6.13	5.79	7.45	4.11	9.19	10.51	7.39	12.13	13.30	7.39	12.13	13.32

Table.3 Effect of different bio regulators on fruit quality of sweet orange

Treatments	TSS (⁰ Brix)			Juice(%)			Acidity (%)		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
T1	10.85	11.27	11.06	37.19	33.79	35.49	0.63	0.74	0.68
T2	11.19	11.22	11.20	37.69	37.28	37.48	0.69	0.78	0.74
T3	10.97	11.42	11.19	39.67	40.10	39.88	0.73	0.84	0.78
T4	10.72	11.05	10.88	41.45	43.16	42.30	0.68	0.87	0.77
T5	11.14	12.00	11.57	40.20	39.04	39.62	0.74	0.79	0.76
T6	11.07	11.48	11.27	39.97	37.57	38.77	0.71	0.73	0.72
T7	11.24	11.35	11.29	42.18	42.94	42.56	0.69	0.70	0.69
T8	11.19	11.78	11.48	39.59	39.02	39.30	0.69	0.81	0.75
T9(Control)	10.50	10.87	10.69	38.17	40.23	39.20	0.72	0.67	0.69
C.D@5%	NS	NS	NS	2.35	NS	2.85	NS	NS	NS
C.V.	3.87	6.23	3.57	5.60	13.36	4.93	11.98	20.85	11.16

Except for juice content, significant differences in the internal quality of fruit were not observed (Table 3). The findings was in line with the observations of Mohan *et al.*, (1986) in Jaffa sweet orange; Medeiros *et al.*, (2000) in Hamlin sweet orange, Antonioli *et al.*, (2003) in Westin sweet orange and Ghosh *et al.*, (2012) in Mosambi sweet orange. The data depicted in table 3 indicates that, there was maximum total soluble solids (11.57⁰Brix) with the foliar spray of Monopotassium phosphate @1.5 % and 2,4-D 10 ppm one month before harvest (T₅). The present results are in a general harmony with Ashraf *et al.*, (2010) who found that that foliar supply of K enhanced the TSS of Kinnow juice. Whereas, low fruit acidity (0.68%) was recorded with the foliar spray of Monopotassium phosphate @ 1 % and 2,4-D 10 ppm one month after fruit set (T₁). Use of plant growth regulators in improving citrus fruit quality including juice percentage is well documented. Highest fruit juice (42.56%) was recorded when plants were sprayed with monopotassium phosphate @1.5 % and GA₃ 10 ppm one month before harvest (T₇) followed by spraying with Urea @ 1% and GA₃ 10 ppm one month after fruit set (T₄). The increase in juice percentage may be explained by the fact that hormones play a

regulating role in the mobilization of metabolites within a plant. These results were in good agreement with that of Nawaz *et al.*, (2008) and Khalid *et al.*, (2012) where they reported the maximum juice content with foliar application of GA₃ as compared to control in Kinnow mandarin. Increased juice percentage may be due to the increased vasculization in the pedicel due to the increased sink strength and reduced senescence and respiration from the fruit (Dhillion *et al.*, 1985) induced with the application of growth regulators.

The results of the present study indicated a significant improvement in fruit growth and yield of Sathgudi sweet orange through foliar application of different growth regulators and macronutrients. Therefore, combined pre-harvest spray of urea @ 1.5 % with 2,4-D @ 10 ppm or GA₃ @ 10 ppm, one month before harvest is recommended in Sathgudi sweet oranges grown in red loamy soils of Andhra Pradesh receiving mean annual rain fall of 600-650mm to achieve better yields.

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