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Effect of Plant Growth Regulators on Fruit Set and Yield of Summer Crop in Acid Lime (*Citrus aurantifolia* Swingle) cv. Balaji

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A B S T R A C T

A field study was conducted at AICRP on Citrus, Citrus Research Station, Tirupati, Andhra Pradesh during the year 2015 under Dr. YSR Horticultural University, to find out Effect of Plant growth Regulators on fruit set and yield parameters of summer crop in acid lime (*Citrus aurantifolia* Swingle) cv. Balaji. Trees were sprayed with treatments *viz.* Spraying GA_3 @ 50 ppm during June + CCC @1000 ppm during September + KNO_3 2% during October, Spraying CCC @ 200 ppm (Chloromequat chloride) 1st in August, 2nd in September followed by light pruning in September and heavy irrigation in mid-October, Application of Paclobutrazol @ 5 ml per meter canopy 4 times at 45 days interval starting from July to December, Spraying NAA @ 200 ppm during December, Spraying 2, 4-D @ 40 ppm during November + 20 ppm during February, Imposition of 30 days of soil moisture stress during October followed by 50 ppm Ascorbic acid spray at release of stress, Spraying ethephon @ 200 ppm during the month of October, With holding irrigation (Bahar) for 30 days in September followed by application of recommended dose of fertilizers and irrigation in the month of November and along with control (Not spray). The data recorded from the results concluded that higher fruit set was recorded with the treatment application of 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5), highest number of fruits per shoot was recorded with application of Paclobutrazol @ 5 ml per meter for four times starting from July to December (T_3), lowest fruit drop percent was recorded with spraying of 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5), number of fruits per tree was recorded with the treatment application of Paclobutrazol @ 5 ml four times starting from July to December (T_3) and Spraying GA_3 @ 50 ppm during June + CCC @ 1000 ppm during September + KNO_3 @ 2 % during October (T_1) has recorded significantly highest fruit yield per tree.

Introduction

In India, among the fruit crops citrus species covers an area of major fruit crops is 10.4% with an area of 953.40 thousand ha, with production of 1,17,42,000 MT, giving rise to Productivity of 8.7 MT per ha estimated data NHB 2015-2016. As per the data available (AP Horticulture online 2015-16), in Andhra Pradesh oranges and Batavia are being cultivated in 1, 21, 716 hectares with the production of 1, 40, 78, 216 MT and limes and lemons are grown an area of 111.09 thousand ha with production of 1717.34 thousand MT and productivity of 16.8 MT per hectares during 2015-2016 (NHB, 2016.).

Citrus is one of the largest and most important groups of fruit crops in tropical and subtropical regions. Acid lime (*Citrus aurantifolia Swingle)* is considered as most important fruit crop (Ghosh, 1990). It is considered to be native of Malayan peninsula. It belongs to the family Rutaceae, with chromosome number (2n=18). It is mainly cultivated for its multi - fold nutritional and medicinal values which made acid lime more important among the fruits.

Its attractive appearance, penetrating aroma of peel and excellent taste gives a remarkable position to acid lime which is grown widely throughout the world (Babu, 2001). Acid lime fruits have great medicinal value. Being acidic in nature, acid lime fruits have great medicinal value. Acid lime is good appetizer, anti helmentic and it checks biliousness and stomach ache. Lime is used in making candy, chocolate, ice cream, pastries and 100 grams of fruit juice contains 80 percent of water, carotene, 26 IU, Vitamin A, Vitamin B_1 20 mg, Riboflavin 0.1 mg, Vitamin C 63 mg, Iron (Fe) 1.83 mg, Copper (Cu) 0.16 mg, Oxalo-acetic acid 0.30%, Malic acid and alkaline salt 8.2% therefore it is very essential for human health (Rangel, 2010).

The major constraints faced by the growers of acid lime are the peak and lean production in consecutive years. Flowering in acid lime is recurrent under tropical and sub-tropical conditions unless synchronized into well-defined period of extreme stress. Since the demand for the fruit remains very high during summer it is very essential to regulate flowering that gives fruiting in the months of April and May which fetches higher returns to the grower compared to the income receive during other seasons.

There is difficulty in fruit set because of incomplete pollination, hence plant growth regulators may be effectively used to increase fruit set. Hasta-bahar (September - October) management through the use of plant growth regulators and chemicals play an important role to get maximum fruit yields during summer (Mukunda *et al.*, 2014). Hence there is a need to test the plant growth [hasta-bahar (September - October)] through the use of plant growth regulators and chemicals for their role inducing flowering for the hasta bahar crop.

Materials and Methods

The present investigation were executed at AICRP on Citrus, Citrus Research Station, Tirupati, Andhra Pradesh during the year 2015 under Dr. YSR Horticultural University with nine treatments *viz.*, Spraying GA_3 @ 50 ppm during June + CCC @1000 ppm during September + KNO_3 2% during October, Spraying CCC @ 200 ppm (Chloromequat chloride) 1st in August, 2nd in September followed by light pruning in September and heavy irrigation in mid-October, Application of Paclobutrazol @ 5 ml per meter canopy 4 times at 45 days interval starting from July to December, Spraying NAA @ 200 ppm during December, Spraying 2, 4-D @ 40 ppm during November + 20 ppm during February, Imposition of 30 days of soil moisture stress during October followed by 50 ppm Ascorbic acid spray at release of stress, Spraying ethephon @ 200 ppm during the month of October, With holding irrigation (Bahar) for 30 days in September followed by application of recommended dose of fertilizers and irrigation in the month of November and along with control (Not spray).

The experiment was laid out in a randomized block design with three replications. The effect of different treatments was studied on fruit set parameters and yield on six randomly selected trees. The mean data were subjected to statistical analysis following analysis of variance technique (Panse and Sukhathme 1985).

Results and Discussion

Percentage of fruit set

The percentage of fruit set in each treatment was recorded and found significant among the treatments. Significantly higher fruit set (89.97%) was recorded on the trees sprayed with 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5) which was found on par (89.67 %) with spraying CCC @ 200 ppm first in August, second in September followed by light pruning in September and heavy irrigation in mid-October (T_2). However, the percentage of fruit set was lowest (65.16 %) in control treatment. The results are in accordance with the findings of Thirugnanavel *et al.,* (2007) who reported higher fruit set by application of GA_3 which might have influenced pollen germination and pollen tube growth.

Further increase in fruit set percentage was also reported by Saleem *et al.,* (2008) and Jain *et al.,* (2014) in mandarin. Higher percentage of fruit set was also found with the application of growth regulators such as 2, 4-D, GA_3 and NAA in kinnow mandarin as reported by Azher Nawaz *et al.,* (2011) Huang and Huang (2005) in Nanfengmiju mandarin and Agusti *et al.,* (1982) in Navelate sweet orange.

Gibberellic acid has been shown to increase fruit set and growth in Clementine orange (Van Rensburg *et al.,* 1996) (Table 1).

No: of fruits per shoot

Highest number of fruits per shoot (6.20) was recorded with application of Paclobutrazol @ 5 ml per meter for four times starting from July to December (T_3) followed by spraying NAA @ 200 ppm (4.05) during December (T_4). Whereas, values for other treatments spraying 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5) (3.84), spraying GA_3 50 ppm during June + CCC @ 1000 ppm during September + KNO_3 2% during October (T_1) (3.48) and 30 days of soil moisture stress during October with 50 ppm ascorbic acid spray at release of stress (T_6) (3.29), sprayings 200 ppm CCC 1st in August, 2nd in September followed by light pruning in September and heavy irrigation in mid-October (T_2) (3.03), were at par with each other.

The lowest number (1.41) of fruits per shoot was in control (T_9). Similar results have been reported by Devi *et al.,* (2011) in acid lime. Narayanlal *et al.,* (2013) who found increase in flowering, fruit growth and number of fruits per shoot with the application of plant growth regulators CCC @ 1000 ppm in guava cv. Allahabad Safeda.

Fruit drop percentage

Fruit drop was recorded in all the treatments and found significant differences. Significantly lowest fruit drop (13.01) percent was recorded with spraying of 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5) which was found on par with spraying GA_3 @ 50 ppm during June + CCC @ 1000 ppm during September + KNO_3 2 % during October (14.41), whereas highest fruit drop (43.71) percent was noticed with control treatment (T_9) followed by spraying ethephon @ 200 ppm during December (35.31) percent.

Similar types of results were obtained by Babu and Lavaniya (1985) who have reported reduced the fruit drop percentage with spray 2, 4-D @ 5 – 20 ppm and GA_3 @ 20 - 40 ppm in Pant lemon-1 and Lima and Davies (1984) in Navel orange 2, 4-D @ 10-20 ppm and GA_3 @ 20 ppm. Randhawa *et al.,* (1959) found in decrease in fruit drop with spraying 2, 4-D @ 15-20 ppm in mandarins and Jaffa sweet orange. Erickson (1951) also reported

reduction of fruit drop with spraying of 2, 4-D @ 8 ppm in Washington navel oranges. The reason for reduction of fruit drop due to 2, 4-D application. It is reputed for its inhibition of fruit drop in various fruit crops by delaying. The development of abscission layer through prevention of loss of pectin material in the middle lamella. So, that stem still alive at longer time.

Table.1 Effect of plant growth regulators on percentage of fruit set, no of fruits per shoot and fruit drop percentage of summer crop in acid lime cv. Balaji

Treatments	**Percentage of fruit set**	**No: of fruits per shoot**	**Fruit drop percentage**
T_1 - Spray GA_3 @ 50 ppm during June + CCC @1000 ppm during September + KNO_3 2 % during October	87.95 (69.73)	3.48	14.41 (22.30)
T_2 - Sprayings 200 ppm CCC (Chloromequat chloride) 1st in august, 2nd in September followed by light pruning in September and heavy irrigation in mid-October	89.67 (71.30)	3.03	19.37 (26.10)
T_3 -Drenching Paclobutrazol @ 5 ml per meter canopy 4 times starting from July to December	80.27 (63.16)	6.20	33.84 (35.54)
T_4 - Spraying NAA @ 200 ppm during December	86.53 (68.44)	4.05	17.03 (24.34)
T_5 - Spraying 2, 4-D @ 40 ppm during November +20 ppm during February	89.97 (71.54)	3.84	13.00 (21.11)
T_6 - 30 days of soil moisture stress during October with 50 ppm Ascorbic acid Spray at release of stress	76.69 (61.11)	3.29	30.85 (33.71)
T_7 - Spraying ethephon @ 200 ppm during October	71.93 (58.00)	2.55	35.31 (36.43)
T_8 – Withholding irrigation (Bahar) for 30 days in September followed by application of recommended dose of fertilizers and irrigation in the month of November	72.89 (58.61)	2.95	31.22 33.94
T_9 - Control	65.16 (53.80)	1.41	43.71 (41.37)
SE(m) ±	1.2	0.157	1.153
CD (5%)	3.627	0.474	3.487

Table.2 Effect of plant growth regulators on no of fruits per tree and fruit yield per tree of summer crop in acid lime cv. Balaji

Treatments	No: of fruits per tree	Fruit yield per tree
T_1 - Spray GA_3 @ 50 ppm during June + CCC @1000 ppm during September + KNO_3 2 % during October	214.83	13.61
T_2 - Sprayings 200 ppm CCC (Chloromequat chloride) 1st in august, 2nd in September followed by light pruning in September and heavy irrigation in mid-October	211.16	10.28
T_3 -Drenching Paclobutrazol @ 5 ml per meter canopy 4 times starting from July to December	234.78	12.08
T_4 - Spraying NAA @ 200 ppm during December	222.55	10.11
T_5 - Spraying 2, 4-D @ 40 ppm during November +20 ppm during February	220.91	9.61
T_6 - 30 days of soil moisture stress during October with 50 ppm Ascorbic acid Spray at release of stress	208.91	9.45
T_7 - Spraying ethephon @ 200 ppm during October	212.54	9.30
T_8 – Withholding irrigation (Bahar) for 30 days in September followed by application of recommended dose of fertilizers and irrigation in the month of November	218.82	9.43
T_9 - Control	167.38	5.41
SE(m) ±	2.165	0.067
CD (5%)	6.547	0.202

Number of fruits per tree

The data pertaining to numbers of fruits harvested per tree has differed significantly between the treatments. Among the various treatments evaluated number of fruits per tree was found significantly highest (234.78) with the treatment application of Paclobutrazol @ 5 ml four times starting from July to December (T_3) which was followed by spraying NAA @ 200 ppm during December (222.56) and all other treatments in the study were found on par with each other. However, lowest number of fruits (167.38) per tree was recorded with the water spray (control). The results are in conformity with findings of Tripathi and Dhakal (2005) and Devi *et al.*, (2011) in acid lime. Goguey (1990) reported increase in the number of fruits per tree with the application of Paclobutrazol 5 ml per tree. Paclobutrazol significantly increases.

Fruit yield per tree

Significant differences were noticed in the yield of acid lime tree due to the sprayings of

different plant growth regulators. Spraying GA_3 @ 50 ppm during June + CCC @ 1000 ppm during September + KNO_3 @ 2 % during October (T_1) has recorded significantly highest fruit yield per tree (13.61 kg) compared to all other treatments fallowed by application of Paclobutrazol @ 5 ml per meter for four times starting from July to December (12.08 kg). The lowest fruit yield was recorded in control treatment (5.41 kg). Similar results were obtained by Mukunda *et al.,* (2014) in acid lime. The increased fruit yield attributed to the synthesis of chlorophyll from source to sink which leads to increase carbohydrate metabolism. This might be due to more vegetative growth attained with GA_3, which increased the vegetative shoot development at the initial sprays. Cycocel sprays during September enhancing flower bud initiation. KNO_3 sprays at later stages could have helped to set more fruits leading highest yield per tree. The results are in agreement with the findings of Thirugnanavel *et al.,* (2007) in acid lime, Jain *et al.,* (2014) high yield noticed with GA_3 100 ppm in Nagpur mandarin. Narayanlal *et al.,* (2013) who reported the highest yield per plant was found in 50 ppm GA_3 in guava. Debbarma and Hazarika (2016) also reported the GA_3 @ 100 ppm + CCC @ 1000 ppm + KNO_3 1 % increases the yield in acid lime (Table 2).

From the investigations it can be concluded that higher fruit set was recorded with the treatment application of 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5), highest number of fruits per shoot was recorded with application of Paclobutrazol @ 5 ml per meter for four times starting from July to December (T_3), lowest fruit drop percent was recorded with spraying of 2, 4-D @ 40 ppm during November + 20 ppm during February (T_5), number of fruits per tree was recorded with the treatment application of Paclobutrazol @ 5 ml four times starting from July to December (T_3) and Spraying GA_3 @ 50 ppm during June + CCC @ 1000 ppm during September + KNO_3 @ 2 % during October (T_1) has recorded significantly highest fruit yield per tree.

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