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Effect of plant growth regulators and micronutrients on reproductive attributes of acid lime (*Citrus aurantifolia* Swingle) in *hasta bahar* cropping season

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ABSTRACT

Plant growth regulators and micronutrients at various combinations [GA_3 50ppm + Cycocel 1000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1%; GA_3 50ppm + Cycocel 2000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1%; GA_3 50ppm + Paclobutrazol 2.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% Boron 0.1%; GA_3 50ppm + Paclobutrazol 3.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1%; GA_3 50ppm + Paclobutrazol 1000ppm (foliar application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1%; and, GA_3 50ppm + Paclobutrazol 2000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1%] were sprayed before flower emergence in acid lime. Minimum days taken to emergence of flower bud (39.57), duration of flowering (24.07), days to 50% fruit set (6.54) and days taken to fruit maturity (145.90) were observed with application of GA_3 50ppm + Paclobutrazol 3.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1% (T_5), whereas, fruit drop (5.92%) was minimum with GA_3 50ppm + Cycocel 2000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1% (T_3). Treatment T_3 also increased the number of flowers per meter length of shoot (49.65) as well as fruit yield (8.90).

Key words: Acid lime, growth regulators, nutrients, flower set, fruit set

INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) belongs to the family Rutaceae. It originated in India and has a chromosome number of 2n=18. Among the various types of citrus fruits grown, acid lime occupies about 3.7 per cent of the total area under citrus in the country. The area under acid lime cultivation in Maharashtra alone is 49.30 hectares, with a production of 739.53MT and productivity of 15.0MT (Anon., 2013).

Acid lime flowers thrice a year, i.e., in the months of January-February, June-July and September-October, under Vidharbha condition and these seasons are generally known as *Ambia*, *Mrig* and *Hasta* bahar, respectively. A bulk of the flowering occurs in *Ambia* bahar (60%), followed by *Mrig* bahar (30%) and *Hasta* bahar (10%). Hence, the market is glutted with *Ambia* bahar fruits, that are harvested in June-July, leading to the lowest price of the fruit during a year in this period. *Hasta* bahar flowering occurs in October-November, and the fruits are ready for harvest in March-May, which is predominately the off-season for acid lime fruits (Thirugananavel *et al*, 2007).

In Vidharbha region, it is highly difficult to regulate *bahar* treatment during September-October due to the absence of sufficient rains. Here, manipulation of *Hasta* bahar flowering with the use of plant growth regulators and other chemicals can serve as an alternative to realize maximum yields during summer, which fetch 6 to 8 times the price of *Ambia* bahar, and 3-4 times the price of *Mrig* bahar season. Keeping the above in view, the present study was aimed at investigating the effect of different combinations of plant growth regulators and micronutrients on reproductive attributes in acid lime in the *Hasta* bahar season.

MATERIAL AND METHODS

A field experiment was conducted in Randomized Block Design (RBD), with three replications, during the year 2013-2014 at the acid lime orchard, College of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, situated at 307-457m above mean sea level, of 20.42°N latitude and 72.02°E longitude. Uniform-sized trees were selected, and the required dose of manures, fertilizers, irrigation and other plant protection measures

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were applied. Treatment combinations used included: T_1 (Control), T_2 (GA_3 50ppm + Cycocel 1000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1%), T_3 (GA_3 50ppm + Cycocel 2000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1%), T_4 [GA_3 50ppm + Paclobutrazol 2.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% Boron 0.1%], T_5 [GA_3 50ppm + Paclobutrazol 3.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1%], T_6 [GA_3 50ppm + Paclobutrazol 1000ppm (foliar application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1%] and T_7 [GA_3 50ppm + Paclobutrazol 2000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1% (foliar application)].

In all the above treatments, water stress for one month was improved from 15th September to 15th October 2013. Spray of plant growth regulators and micronutrients was scheduled as: (i) GA_3 was applied in the first fortnight of June, (ii) Cycocel and Paclobutrazol were sprayed at release of trees from water stress (i.e., 15th September), (iii) Spray of KNO_3, zinc and boron 2 to 3 days prior to release of water stress (i.e., 15th October). Observations were recorded on days taken to emergence of flower-bud, number of flowers per meter length of shoot, duration of flowering, days required for 50% fruit set, fruit drop (%), days to fruit maturity, and yield (t/ha).

RESULTS AND DISCUSSION

Days required for emergence of flower-bud in acid lime was significantly influenced by plant growth regulators and micronutrients (Table 1). After imposition of the treatments, minimum number of days required for emergence of flower-bud (39.57) was observed in treatment T_5 [GA_3 50ppm + Paclobutrazol 3.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1%], which was significantly superior to all the other treatments. Maximum number of days taken for emergence of flower-bud (54.67) was seen in treatment T_1. Similar results were obtained earlier in acid lime, treated with micronutrients and Paclobutrazol (Baskaran *et al*, 2010; Haribabu and Rajput 1982). Similarly, Khanduja *et al* (1974) observed in grape-vine, that zinc promoted nucleic acid synthesis, in turn influencing the formation of flower-bud primordia. Arora (1969) also observed earlier flowering in guava with application of zinc. It is clear from Table 1 that the number of flowers per meter length of shoot was significantly influenced by growth regulators and micronutrients in our study on acid lime. Maximum (49.65) number of flowers per meter length of shoot was observed in treatment T_3 which was significantly superior to all the other treatments, followed by T_5 (44.25) and T_2 (42.63), which were at par with each other. The lowest number of flowers per meter length of shoot (21.40) was recorded in Control (T_1).

Duration of flowering in acid lime under various treatments in our study was found to be non-significant (Table 1). Kachru *et al* (1971) demonstrated that gibberellic acid inhibited flowering in mango, as, higher levels of GA_3 are antagonistic to formation of flower primordial; high levels of endogenous auxins and low levels of endogenous gibberellin favour flower-bud initiation. Paclobutrazol and Cycocel are known inhibitors of gibberellin biosynthesis. Reduced levels of endogenous gibberellins resulting from action of these chemicals may favour early and profuse flowering in mango (Kurian and Iyer, 1993). Growth retardants (Paclobutrazol and Cycocel) have anti-gibberellin effect which, in turn, checks vegetative growth and promotes early flowering. Results depicted in Table 1 reveal that the

Table 1. Effect of different concentrations/ combinations of GA_3, Cycocel, KNO_3, zinc, boron and Paclobutrazol on flowering parameters, fruit set, fruit drop and fruit maturity of acid lime (C*itrus aurantifolia* swingle).

Treatment	Days taken to emergence of flower bud	Flowers per meter length of shoot	Duration of flowering	Days to 50% fruit set	Fruit drop %	Days taken to fruit maturity	Yield kg/plant
T_1	54.67	21.40	31.33	11.05	12.36 (3.52)	164.50	11.64
T_2	46.87	42.63	29.33	9.36	6.85 (2.62)	156.70	30.58
T_3	44.56	49.65	27.67	8.40	5.92 (2.43)	154.40	32.29
T_4	42.77	40.20	26.45	7.68	8.62 (2.94)	149.60	25.63
T_5	39.57	44.25	24.07	6.54	7.96 (2.82)	145.90	31.12
T_6	51.08	32.40	30.87	10.88	9.25 (3.04)	161.30	20.43
T_7	49.12	36.40	30.45	9.48	9.03 (3.00)	157.70	24.41
'F'-test	*	*	NS	*	*	*	*
SE(m)±	1.44	1.00	1.56	0.51	0.25	2.88	0.66
CD *(P=0.05)*	4.46	3.08	4.82	1.59	0.80	8.89	2.04

NS = Non-significant; *

number of days required for 50% fruit set in acid lime under various treatments was significantly influenced by plant growth regulators and micronutrients. Treatment T_5 recorded minimum (6.54) number of days for 50% fruit-set, followed by T_4 (7.68) and T_3 (8.40), while, maximum number of days taken for 50% fruit-set was recorded in treatment T_1 (11.05). Application of Cycocel and Paclobutrazol (known anti-gibberellins) cause effective translocation of carbohydrates besides causing a positive effect of cytokinins and auxins in conversion of vegetative buds to flower buds. Similar results were reported in lemon (Monselise *et al*, 1966), mango (Maiti *et al*, 1971) and 'Eureka' lemon (Nir *et al*, 1972). Greenburg *et al* (1993) observed higher fruiting in orange cv. 'Shamouti' on application of Paclobutrazol.

Data depicted in Table 1 reveal that fruit drop in acid lime is significantly influenced by plant growth regulators and micronutrients. Minimum fruit drop was recorded in treatment T_3 (5.92%), which was significantly superior to all the other treatments, followed by T_2 (6.85%), T_5 (7.96%) and T_7 (9.03%). Treatment T_1 (12.36%) showed maximum fruit drop. Haribabu and Rajput (1979) reported in *kagzi* lime that spraying zinc sulphate inhibited abscission, thereby reducing flower and fruit drop. The number of days required to fruit maturity in acid lime was found to be significantly influenced by plant growth regulators and micronutrients (Table 1). Significantly lower number of days (145.90) were required for fruit maturity in treatment $T_{5,}$ which was significantly superior to all the other treatments. Treatments T_3 (154.40 days), T_2 (156.70 days) and T_7 (157.70 days) were at par with each other. However, treatment T_1 (Control) took maximum number of days for fruit maturity (164.50).

Table 2. Details of treatments applied

Treatment	Treatment details
T_1	Control
T_2	GA_3 50ppm + Cycocel 1000ppm + KNO_3 (0.2%) + Zn (0.3%) + Boron (0.1%)
T_3	GA_3 50ppm + Cycocel 2000ppm + KNO_3 (0.2%) + Zn (0.3%) + Boron (0.1%)
T_4	GA_3 50ppm +Paclobutrazol 2.5g a.i./tree (soil application) + KNO_3 (0.2%) + Zn (0.3%) + Boron (0.1%)
T_5	GA_3 50ppm + Paclobutrazol 3.5g a.i./tree (soil application) + KNO_3 (0.2%) + Zn (0.3%) + Boron (0.1%)
T_6	GA_3 50ppm + KNO_3 (0.2%) + Zn (0.3%) + Boron (0.1%) + Paclobutrazol 1000ppm (foliar application)
T_7	GA_3 50ppm + KNO_3 (0.2%) + Zn (0.3%) + Boron (0.1%) + Paclobutrazol 2000ppm (foliar application)

Paclobutrazol advances flowering, and ultimately results in early maturity of the fruits.

Significantly high yield (8.90t/ha) was obtained in treatment T_3, followed by T_5 (8.62 t/ha), which was significantly superior to all the other treatments; minimum yield (3.22 t/ha) was seen in T_1 (Control). Appropriate combinations and concentrations of growth regulators and micronutrients (GA_3 50ppm+ Cycocel 2000ppm + KNO_3 0.2% + Zinc 0.3% + Boron 0.1%, and utilization of these at the appropriate stage, along with water stress, is effective in regulation of *Hasta* bahar. This is achieved by maximizing the number of fruits and increasing fruit yield harvested during March-April when the demand is higher and prices are at an all-time high. Based on the above findings, appropriate combinations and concentrations of growth regulators, and, micronutrients, i.e., GA_3 50ppm+Cycocel 2000ppm + KNO_3 0.2% +Zinc 0.3% + Boron 0.1%, along with imposition of water stress, was found by us to be effective.

This can be very well achieved by applying T_3 and T_5 for increasing fruit yield to be harvested during March - April. Thus, timely application of the treatments GA_3 50ppm + Cycocel 2000ppm + KNO_3 0.2% + Zn 0.3% + Boron 0.1% (T_3), and, GA_3 50ppm + Paclobutrazol 3.5g a.i./tree (soil application) + KNO_3 0.2% + Zn 0.3% + Boron 0.1% (T_5) promise higher returns to the acid lime grower.

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