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Effect of growth regulators, micronutrients and chemicals on yield, yield attributes and economics of acid lime cv- Vikram in Ambebahar under high density planting system (*Citrus aurantifolia* Swingle)

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Abstract
The experiment was conducted in Randomized Complete Block Design with three replications during 2016-17 & 2017-18 to assess the performance of growth regulators, micronutrients and chemicals on yield and yield traits of acid lime. The experiment was conducted on the Experimental area, College of Agriculture, Gwalior (M.P.). The role of growth regulators, micronutrients and chemicals is very crucial in growth and quality improvement of fruit crops. Study was undertaken to investigate the different combinations of plant growth regulators (GA_3 and NAA), micronutrients ($FeSO_4$ and Boron) and chemicals (KNO_3 and Salicylic acid). Treatment GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) shows significant variance regarding fruit length (4.64 cm), fruit diameter (4.59 cm), average fruit volume at harvest (41.8 cc), number of fruits perplant (974.2) and average yield per tree (38.3 kg). Treatment (T_{11}) observed maximum net income (Rs. 79,852.5) with highest cost benefit ratio (1:1.71).

Keywords: GA_3, NAA, $FeSO_4$, Boron, Fruit length, Fruit diameter, fruit per plant, yield

Introduction
Acid lime (*C. aurantifolia* Swingle), a member of Rutaceae family, is native of India. The acid lime is extensively grown in almost all parts of tropical and subtropical regions. It is highly polyembryonic distinct species of lime has great commercial importance. The flowering and fruiting takes place throughout year. India ranks fifth among major lime and lemon producing countries in the world. India is the largest producer of acid lime in the world. The acid lime occupies 2.83 lakh hectares with the production and productivity of 32.21 lakh tons and 12.3 tons/ha respectively (Anonymous, 2017) [4]. Acid lime fruits grow best between a temperature ranges of 13 ^{0}C to 37 ^{0}C. Temperatures below – 4 ^{0}C is harmful for the young plants.
Acid lime is rich in vitamin C, minerals and salts. The seasonality of production leads to market glut which results in poor returns to the farmers. In recent years, chemical regulation of flowering and fruiting has been successfully proven in several fruit crops. In citrus, use of plant growth regulators for promoting or inhibiting flowering has been suggested by Moss (1969) [3] and Iwahori and Oohata (1981) [2]. GA3 is well-known in promoting flower growth and development, its involvement in controlling the delay of senescence is less clear. There have been reports that GA3 has little effect as an ethylene inhibitor, inhibiting both climacteric ethylene production and flower senescence (Beyer, 1976). Exogenously supplied micronutrients were shown to affect a large variety of processes in plants, including stomatal closure, seed germinationand fruit yield.

Method and Material
The experiment will be laid out in Randomized Block Design with three replications. The experiment comprised of 13 treatments consisting of use of plant growth regulators, micronutrients and chemicalsduring 2016-17 & 2017-18. Treatment consisted of T_1: Control (water spray), T_2: GA_3 50 ppm + KNO_3 1%, T_3: GA_3 100 ppm + KNO_3 2%, T_4: GA_3 50 ppm + Salicylic acid 100ppm, T_5: GA_3 100 ppm + Salicylic acid 200ppm, T_6: NAA 200ppm + KNO_3 1%, T_7: NAA 300ppm + KNO_3 2%, T_8: NAA 200ppm + Salicylic acid 100ppm, T_9: NAA 300ppm + Salicylic acid 200ppm, T_{10}: GA_3 50 ppm + KNO_3 1% + Salicylic acid 100ppm + $FeSo_4$ 0.5% + Boron 0.5%, T_{11}: GA_3 100 ppm + KNO_3 2% + Salicylic acid 200ppm + $FeSo_4$ 1% + Boron 1%, T_{12}: NAA 200ppm +KNO_3 1% + Salicylic acid 100ppm + $FeSo_4$0.5% + Boron 0.5%, T_{13}: NAA 300ppm +KNO_3 2% + Salicylic acid 200ppm + $FeSo_4$ 1% + Boron 1%.

All treatments replicated thrice. One tree will be used for each treatment. The treatment imposed four months before flowering in October followed by January-February through foliar spray.

The data were recorded for reproductive and quality traits *viz.*, fruit length, fruit diameter, average fruit volume at harvest, number of fruits Perplant and average yield per tree.

Result and Discussion

Pooled data analysis showed significant difference in fruit length, fruit diameter, fruit volume at harvest, number of fruits perplant and average yield per tree and also for both years (Table 1).

Table 1: Effect of growth regulators, micronutrients and chemicals on yield attributes and economics of acid lime

Treatments	FL (cm)	FD (cm)	AFV (cc)	NFPP	Yield (kg)	B:C Ratio
T_1	4.20	4.15	23.9	797.5	21.8	1.71
T_2	4.35	4.29	26.1	882.7	24.5	1.90
T_3	4.38	4.33	27.6	905.5	26.1	2.01
T_4	4.47	4.41	30.8	940.8	29.1	2.19
T_5	4.49	4.44	33.5	946.2	30.8	2.23
T_6	4.40	4.35	28.2	929.8	26.8	2.10
T_7	4.44	4.38	29.9	933.8	27.6	2.15
T_8	4.51	4.46	35.0	948.8	32.0	2.42
T_9	4.53	4.48	36.2	950.8	33.4	2.44
T_{10}	4.56	4.50	38.2	956.3	34.8	2.59
T_{11}	4.64	4.59	41.8	974.2	38.3	2.71
T_{12}	4.57	4.52	38.8	963.8	35.5	2.60
T_{13}	4.61	4.55	40.5	966.2	37.0	2.64
S.Em ±	0.027	0.031	2.639	3.401	2.030	-
CD 5%	0.076	0.088	7.427	9.572	5.796	-

*T_1: Control (water spray), T_2:GA_3 50 ppm + KNO_3 1%, T_3: GA_3 100 ppm + KNO_3 2%, T_4: GA_3 50 ppm + Salicylic acid 100ppm, T_5: GA_3 100 ppm + Salicylic acid 200ppm, T_6: NAA 200ppm + KNO_3 1%, T_7: NAA 300ppm + KNO_3 2%, T_8: NAA 200ppm + Salicylic acid 100ppm, T_9: NAA 300ppm + Salicylic acid 200ppm, T_{10}: GA_3 50 ppm + KNO_3 1% + Salicylic acid 100ppm + $FeSo_4$ 0.5% + Boron 0.5%, T_{11}: GA_3 100 ppm + KNO_3 2% + Salicylic acid 200ppm + $FeSo_4$ 1% + Boron 1%, T_{12}: NAA 200ppm +KNO_3 1% + Salicylic acid 100ppm + $FeSo_4$ 0.5% + Boron 0.5%, T_{13}: NAA 300ppm +KNO_3 2% + Salicylic acid 200ppm + $FeSo_4$ 1% + Boron 1%

*Fruit length (cm): FL (cm), Fruit diameter (cm): FD (cm), Average fruit volume (cc) at harvest: AFV (cc), Number of fruits Perplant: NFPP, Average yield(kg/plant): Yield (kg),Economics: ECO

Treatment receiving GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) (4.64 cm) recorded highest fruit length among all treatments which was at par with treatment NAA 300 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{13}) (4.61 cm), NAA 200 ppm +KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5% (T_{12}) (4.57 cm), GA_3 50 ppm + KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5%(T_{10}) (4.56 cm), NAA 300 ppm + Salicylic acid 200 ppm(T_9) (4.53 cm) and NAA 200 ppm + Salicylic acid 100 ppm(T_8) (4.51 cm).

Significant and highest fruit diameter among all treatments was recorded in GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) (4.59 cm) which was at par with treatment NAA 300 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{13}) (4.55 cm), NAA 200 ppm +KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5% (T_{12}) (4.52 cm) and GA_3 50 ppm + KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5%(T_{10}) (4.50 cm).

Maximum average fruit volume (cc) at harvest were premeditated in treatment GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) (41.8 cc) which was significantly at par with treatment NAA 300 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{13}) (40.5 cc).

Maximum number of fruits perplant was premeditated in treatment GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) recorded maximum number of fruits perplant (974.2) which was significantly at par with treatment NAA 300 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{13}) (966.2).

Maximum average yield per plantwas premeditated in treatment GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) (38.3 kg) which was significantly at par with treatment NAA 300 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{13}) (37.0 kg), NAA 200 ppm +KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5% (T_{12}) (35.5 kg), GA_3 50 ppm + KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5%(T_{10})(34.8 kg), NAA 300 ppm + Salicylic acid 200 ppm(T_9) (33.4 kg) and NAA 200 ppm + Salicylic acid 100 ppm(T_8) (32.0 kg).

treatment GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) observed maximum net income (Rs. 79,852.5) with highest cost benefit ratio (1:2.71) which was followed by treatment NAA 300 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{13}) (1:2.64), NAA 200 ppm +KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5% (T_{12}) (1:2.60), GA_3 50 ppm + KNO_3 1% + Salicylic acid 100 ppm + $FeSo_4$ 0.5% + Boron 0.5%(T_{10}) (1:2.59), NAA 300 ppm + Salicylic acid 200 ppm(T_9) (1:2.44) and NAA 200 ppm + Salicylic acid 100 ppm(T_8) (1:2.42).

Boron and $FeSo_4$ reflects into increase in fruit yield traits along with growth regulators. A treatment which includes good amount of micronutrients helps to regulate nutrient flow in fruit (Shukla, H.S. (2009) [11], Jagtap *et al.*, 2013) [8]. Growth regulators such as GA_3 and NAA along with micronutrients also contribute towards increase in length, diameter of fruit which results into increase in fruit volume (Debaje *et al.*, 2011) [6]. Optimum dose of growth regulators along with micronutrients enhance all traits responsible for number of fruits per plant. Growth regulators responsible for retain more flowers per plant while micronutrient helps to

improve its quality. All components contributed toward increase in number of fruits per plant (Eman, A.A. *et al.* (2007) [5], Kachave D.B. and Bhosale A.M., 2007) [9]. Treatment GA_3 100 ppm + KNO_3 2% + Salicylic acid 200 ppm + $FeSo_4$ 1% + Boron 1% (T_{11}) shows continuous increase in average yield over both year. Yield attributing traits such as number of fruits per tree, average fruit weight contributes towards average yield. Growth regulators such as GA_3 and NAA followed by micronutrients and chemicals in combinations aids to boost basic characters supporting fruit yield per plant and also signify in economics. Treatment which lacks treatment dose remarks with lower in yields (Debbarma N. and Hazarika B.N. (2016) [7], Lal N. *et al.*, 2017) [10].

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