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HORTICULTURE

Effect of plant growth regulators and chemicals on yield and quality of acid lime (*Citrus aurantifolia* Swingle) under foothill condition of Arunachal Pradesh

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Abstract

An experiment to study the effect of plant growth regulators and chemicals on acid lime (*Citrus aurantifolia* Swingle) was carried out in the year 2014 in the Experimental Farm, Department of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The experiment was laid out in Randomized Block Design with eight treatments and three replications. The treatments were T_1 (control – water spray), T_2 (GA 50 ppm), T_3 (GA 100 ppm), T_4 (Cycocel 1000 ppm), T_5 (KNO_3 one percent), T_6 (GA_3 50 ppm + Cycocel 1000ppm), T7 (GA_3 100 ppm + Cycocel 1000 ppm), T_8 (GA_3 100 + Cycocel 1000ppm +KNO_3 1 per cent. The experimental results indicate that the acid lime trees sprayed with GA_3 100 ppm + Cycocel 1000ppm + KNO_3 1 per cent showed better performance in delaying of flowering, increase the number of flower/shoot (6.62), number of fruits /tree (149) and average fruit yield (4.64 kg / tree) of the crop. Effect of growth regulators and chemicals on quality characters however was not found significant for most of the parameters except TSS, ascorbic acid and titrable acidity. The higher results were obtained in T_8 i.e. GA_3 100 ppm + Cycocel 1000ppm + KNO_3 1 per cent (8.27%) for titrable acidity and ascorbic acid (41.21 mg). Control with water spray alone registered the lowest values for both quantitative and qualititative parameters.

Highlights

- Acid lime with application of GA3 100 ppm+ Cycocel 1000ppm+KNO3 1 per cent recorded the maximum content of reducing (0.32%), non-reducing (0.31%), and total (0.62%) sugars under foothill condition of Arunachal Pradesh.

Keywords: Plant growth regulators, acid lime, flowering, fruiting, yield

Acid lime (*Citrus aurantifolia* Swingle) is the third important citrus fruit crop in India next to mandarin and sweet orange. Limes are commercially grown in tropical and sub - tropical regions of India. Limes belong to the family *Rutaceae.* It has originated in India (North Eastern India) and adjoining portions of Burma or northern Malaysia. It is generally grown under both tropical and sub - tropical climatic conditions in the plains and up to 1000m above mean sea level, provided humidity is low and favorable. In more humid regions where rainfall is above 1,250mm, lime is highly susceptible to citrus canker and powdery mildew making the trees unproductive and short lives (Chadha 2003). Acid lime is highly polyembyonic. Trees are small, bushy with small but sharp spines. Leaves small with narrowly winged petioles. Flowers and fruits are small. Fruits are round to oval. However, Bhattacharya and Dutta (1956) observed round, long or oblong shaped fruits. Similar observation was also reported by Bhan (1972). Fruits mature irregularly throughout the year, greenish yellow in colour and juice is highly acidic. Seeds are small, smooth and cotyledons whitish. Acid lime is appreciable not only for its beautiful appearance and pleasing flavour but also for its excellent fruit qualities. Limes are used as fresh fruit, preparation of pickles and beverages. Lime is a good source of vitamin C and has a good antioxidant property. The fruit is valued not only for its nutritional qualities but also for pharmaceutical, nutraceutical, cosmeceutical, medicinal and health sector with its great potential growth. The value addition to fresh fruits in terms of nutrition, economics and convenience for handling, transportations, storage and form to export of processed fruits are more than that of fresh produce. The production of large amounts of value added and processed products dictate evolution of significant by products industry to utilize the peel residue, essential oils and other components as well as a search for new products and uses. The flowering in citrus under Indian conditions is induced through either low temperature stress or soil water deficit stress. Chilling temperatures induce flowering of citrus. Temperature of 20° to 26°C day and 8° to 12°C night produces up to 100% of the terminal to flowers where as day temperature of 32° to 39°C prevented flowering. Precipitation less than 100 to 150 mm per month is sufficient to induce flowering when the trees are relieved of stress. A major flush of vegetative growth coincides with the spring flowering flush and sporadically in distinct flushes throughout the warm months under subtropical conditions. In India, commercially acid lime is grown in Andhra Pradesh, Gujarat, Orissa, Karnataka and Maharashtra with a share of 34, 14, 9, 8 and 6 percent respectively (Dandin and Patil, 2010). Besides, recent data also revealed that in India, Andhra Pradesh top in lime production 33% followed by Gujarat 19% and Maharashtra (12%) Owing to its refreshing, nutritional, medicinal properties and industrial importance acid lime is gaining popularities across the country. Though it is generally grown under both tropical and subtropical climatic condition, however, acid lime is not grown like lemon or other citrus fruits in the North Eastern Region as a whole. In India, limes are still grown in home garden and hence the cultivation and improvement of lime did not receive much attention till date. There is an urgent need for regulation of cropping and fruit maturity in limes. In spite of great demand for this fruit, the commercial cultivation of acid lime have not been taken up so far in many feasible areas. The major constraints faced by growers of acid lime are the peak and lean production of the trees in a year. The application of growth regulators have been found to be beneficial in increasing the fruit set in many crops like apple, citrus mango, grapes etc. They help in the development of ovary and checking the abscission. Earlier reports indicate that external application of growth regulators at full bloom increase fruit set and yield in sweet lime (Chundawat and Randhawa 1971). Out of available plant growth regulators, some influences the flowering and fruiting in citrus crop. Gibberellins may be defined as compound that has gibbane skeleton and this stimulates cell division or cell elongation or both. Gibberellins can cause a striking increase in shoot elongation. It influence flowering in citrus as the root - produced gibberellins play an important role in flowering through inhibiting effect on generative shoot production. Besides, it influences the intensity of flowering by reducing bud sprouting. Gibberellins applied during the inductive period show a reduction of leafless inflorescence especially with no effect on vegetative shoots. Cycocel, a growth retardant which is act as an antigibberellin compound and arrested the vegetative bud development, nucleic acid synthesis and protein metabolism by specific anti-metabolites, which induce flower formation. (Nir *et al.* 1972). Potassium is known for development of fruit, movement of sugars and indirectly photosynthesis (Debaje *et al.* 2006). Since potassium enhances internal fruit quality while gibberellic acid enhances fruit set, promotes cell elongation and growth of fruit. Considering the potential of the crop, there is need to study the performance of the crop under the foothills of Arunachal Pradesh as there is no such information for this crop under this situation. Further regulation of flowering can give a scope for harnessing its potential to a great extent. Therefore, the present study was programmed to study the effect of growth regulators and chemicals on yield and quality of acid lime under the foothills of Arunachal Pradesh.

Materials and methods

The experimental was conducted in the experimental farm, Departmental of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The Fruit research farm is situated in the foot hills of Eastern Himalayan range at an altitude of 153 m above mean sea level, 28°04′ North latitude and

95°22′ East longitudes. The soil of the experimental site is slightly acidic soil of nearly pH 5.7 having sufficient depth, moderately fertile and having proper drainage. The climate of the area is humid-subtropical. The monsoon starts in the month of June and often remains active up to September. But pre-monsoon rain starts from the month of May and post-monsoon rain prevails up to October. The experiment was laid out in Randomized Block Design (RBD) with three replication and eight treatments. Four year old uniform acid lime trees were selected for the experiment. The variety of Acid Lime selected for study was PK M-1. Two trees were used for each treatment. The treatments tried were T_1 (control – water spray), T_2 (GA_3 50 ppm), T_3 (GA_3 100 ppm), T_4 (Cycocel 1000 ppm), T_5 (KNO_3 one percent), T_6 (GA_3 50 ppm + Cycocel 1000 ppm), T7 (GA_3 100 ppm + Cycocel 1000 ppm), T_8 (GA_3 100 ppm + Cycocel 1000ppm +KNO_3 1 per cent).The aqueous solution of the growth regulators viz., GA and cycocel, and chemicals viz., KNO_3, were sprayed thoroughly on the foliage of the selected trees on the early morning till the point of run off. GA_3 was applied during June, Cycocel was applied during the month of September and KNO_3 was applied during October. The observations on growth and yield parameters were were recorded and presented.

Results and discussion

Flowering and fruiting

Number of days to first flowering is an important criterion that governs either delay or earliness of a crop. It is influenced by diverse factors like genetic, environmental, physiological, nutritional, hormonal and cultural practices. In the present study, the different treatments significantly delayed the flowering. The highest delay in flowering was observed in trees sprayed with GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1 per cent by nearly two months when compared to control. This might be due to more vegetative growth by GA_3, (Table 1) which reduced the generative shoot and increased the vegetative shoot development which are also supported by the study of Iwahori and Oohata (1981) in Satsuma mandarin and in citrus by Monselise (1977).Cycocel, a growth retardant which was sprayed in September, might have acted as an antigibberellin compound and arrested the vegetative bud development, nucleic acid synthesis and protein metabolism by specific antimetabolites, which induce flower formation. Similar results were also reported by Nir *et al.* (1972).

The number of flowers / shoot (6.62) and fruit set (65.51%) were the highest in GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1per cent treated trees (Table 1). The higher fruit set by GA_3 application might have been due to its beneficial effects on pollen germination and pollen tube growth. Similar increase in fruit set by GA_3treatment was reported in acid lime (Babu *et al.* 1984). GA's role in promoting growth and inhibition of flowering at higher concentration was in conformity with the observation of Thirungnanavel *et al.* (2007). The KNO_3 application during the later stage could also have helped the trees to set more fruits Parthiban *et al*. (2010).

The highest fruit retention was noticed in tree sprayed with GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1per cent which retained 2.63 fruits / shoot at harvest (Table 1). The spraying of plant growth regulators and chemicals enhanced the auxin production, which in turn controlled abscission Parthiban et al.,(2010). This is in conformity with findings of Saraswathi *et al*. (2002).

Yield is the culmination of the interplay of several factors like biochemical, physiological characters and yield parameters. The purpose of all cultural operations is to manipulate these and thereby increased the yield. The increased yield attributed to the synthesis of chlorophyll which leads to the increased carbohydrate metabolism from source to sink. Highest number (149 fruits / tree) were obtained in GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1 per cent which may be due to the number of flowers and comparatively higher retention of fruits (Table 1)). The increase in yield may be due to more fruit set, fruit retention and numbers of fruits / tree. These results are in agreement with the findings of Shrestha (1988). Higher yield in mango as reported by Sanyal *et al.* (1996) by KNO_3 also supported the findings of present study.

Quality attributes

The highest fruit length, fruit diameter, fruit volume and fruit weight was recorded in GA_3 50 ppm (Table 2). The fruit weight was observed to be significantly increased by plant growth regulators application over control. In case of GA_3 the weight of the fruit increased with the increase of concentration of the growth regulators while in cycocel at high concentration reduced the fruit weight. Reduction in the fruit weight may be due to the suppression of GA by the cycocel which result in reduction of cell elongation in the fruits during the fruit development. This findings are in conformity with the findings of Parthiban *et al*., (2010). The number of seed reduced in all the treatments as compared to control. The lowest number of seed was observed in Cycocel 1000ppm. GA treatment also resulted in less number of seed (Table 2). The less seed number in GA_3 may be due to parthenocarpy effect of GA_3.

The effect of growth regulators however did not reflect significant influence in most of the biochemical parameters other than total soluble solids and titrable acidity. Variation in the level of TSS might be due to the fact that GA_3stimulate the functioning of number of enzymes in the physiological process, which probably caused an increase TSS in those treatments. The findings of Nath and Barauh (2000) in Assam lemon, Singh *et al.*, (1987) in ber and Kumar and Singh (1993) in mango has supported the fact that there is increase in TSS with application of GA_3.

The highest acidity (8.27%) and ascorbic acid content (41.21 mg/100ml) were recorded in the treatment with a spray of GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1 per cent.

The total soluble solids, acidity and ascorbic acid content are the very important attributes that decide the quality of acid lime. The highest acidity of the fruit was recorded in GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1 per cent. Increase in acidity of fruit was reported by Sharma *et al*,(2003) in mandarin with GA_3.

The highest ascorbic acid was recorded in GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1 per cent. The reason for increase in ascorbic acid content in fruits by GA_3 treatment was attributed to perpetual synthesis of glucose-6-phosphate through the development fruits, which is considered as precursor of vitamin C (Nath and Baruah, 2000). Similar results of increased level of ascorbic acid content by GA_3application were also obtained by Singh *et al*., (1987) in ber and Kumar and Singh (1993) in mango. The sugars are indirectly proportional to acidity (Shrestha, 1988). Quality characters such as reducing sugar, non-reducing sugar and total sugars did not significantly among the treatments. In the present study, higher proportion of reducing sugar than non-reducing sugar was observed in all the treatments in general. Similar results have been reported by Singh and Lal (1982). The plants with application of GA_3 100 ppm+ Cycocel 1000ppm+KNO_3 1 per cent recorded the maximum content of reducing (0.32%), non-reducing (0.31%), and total (0.62%) sugars.

Table 1: Effect of plant growth regulators and chemicals on flowering and yield

Treatments	Days to first flowering	Number of flower per shoot	% increased over control	Fruit set % / shoot	Fruit retention/ shoot at harvest	Number of fruits/ tree	Yield (kg/ tree)
T_1	75.00	3.38		63.52	1.12	87.00	2.35
T_2	105.00	6.12	80.06	55.48	2.12	117.00	3.56
T_3	113.00	5.97	76.22	55.93	2.02	113.00	3.51
T_4	94.00	6.13	81.66	50.80	1.93	102.00	2.94
T_5	117.00	6.23	84.31	51.50	2.10	108.00	3.10
T_6	98.00	5.80	71.59	61.65	1.92	126.00	3.84
T_7	122.00	6.15	81.95	59.89	1.97	134.00	4.04
T_8	128.00	6.62	95.85	65.51	2.63	149.00	4.64
SEd(±)	2.33	0.09		2.06	0.04	2.29	0.23
$CD_{5\%}$	5.00	0.20		4.43	0.09	4.93	0.50

Table 2: Effect of plant growth regulators and chemicals on physical characters of fruit

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Volume of fruit (cc)	Weight of fruit (gm)	Number of seed per fruit	Juice content / Fruit (ml)
T_1	3.65	3.64	36.06	27.00	12.27	13.09
T_2	4.43	4.45	45.63	33.27	10.10	17.53
T_3	4.17	4.15	41.41	31.15	11.33	16.60
T_4	4.08	3.97	39.42	28.81	9.67	14.83
T_5	3.95	3.99	38.49	29.50	11.07	15.07
T_6	3.72	4.13	40.01	30.50	11.40	15.60
T_7	3.79	4.11	40.13	30.18	10.13	16.27
T_8	4.23	4.20	40.98	31.16	10.73	17.27
SEd (±)	0.02	0.04	0.69	1.11	0.09	0.13
$CD_{5\%}$	0.05	0.09	1.49	2.39	0.21	0.28

Table 3: Effect of plant growth regulators and chemicals on biochemical components of fruit

Treatments	Total Soluble Solids (TSS) °Brix	Titrable acidity (%)	Reducing sugar (%)	Non Reducing sugar (%)	Total sugar (%)	Ascorbic acid mg/100 ml
T_1	6.20	6.07	0.24	0.22	0.46	30.41
T_2	7.47	6.34	0.29	0.26	0.55	34.23
T_3	7.07	6.47	0.28	0.26	0.54	33.77
T_4	6.33	7.05	0.26	0.24	0.51	35.65
T_5	6.67	6.67	0.25	0.23	0.48	34.81
T_6	6.80	7.48	0.28	0.26	0.53	33.90
T_7	7.00	7.83	0.30	0.27	0.58	36.67
T_8	7.13	8.27	0.32	0.31	0.62	41.21
SEd (±)	0.069	0.05	…….	……..	……..	1.65
$CD_{5\%}$	0.14	0.11	NS	NS	NS	3.55

*N.S:Non Significant

References

Babu, R.S.H., Rajput, C.B.S. and Rath, S. 1984. Effects of Zn, 2,4-D and GA_3 on fruiting of Kagzi lime (*Citrus aurantifolia* Swingle). *Indian Journal of Horticulture* **41**(3/4): 216 - 220.

Bhan, K.C. 1972. Citrus Industry in Eastern India, Bihar, Orissa and West Bengal states. *Proceedings 1st All India seminar on Citriculture,* Nagpur, p. 24.

Bhattacharya, S.C. and Dutta, S. 1956. *Classification of citrus fruits of Assam*. Scientific monograph. No. 20. 1. C.A.R., pp. 39 – 41.

Chadha, K.L. 2003. Limes and Lemons. In: Handbook of Horticulture. Published by Directorate of Information and Publication of Agriculture, ICAR, Krishi Anusandhan Bhavan, Pusa, New Delhi 110 012.

Chundawat, B.S. and Randhawa, G.S. 1971. Studies on fruit set ad fruit drop in sweet lime (*Citrus limettoides* Tanaka). *Journal of the Japanese Society for Horticultural Science* **40**(2): 115 - 120.

Dandin, S.B. and Patil, D.R. 2010. Problems and prospectus of citrus production in India with special reference to acid lime (*Citrus aurantifolia* Swingle) cultivation in Karnataka. *Proceeding of National Seminar on "Citrus Biodiversity for livelihood and Nutritional Security"*, October 4-5, 2010, NRC, Citrus, Nagpur, Maharashtra. pp.111-118.

Debaje, P., Ekta, P., Shine, D. and Ingale H.V. 2011. Effect of plant growth regulators and nutrients on quality of Acid lime (Citrus aurantifolia Swingle). *The Asian Journal of Horticulture* **6**(1): 253 – 255.

Iwahori, S. and Oohata, J.T. 1981. Control of flowering of Satsuma mandarin (*Citrus unshiu* Marc.) with gibberellins. *Proceedings International Society of Citriculture.* pp.247-249.

Kumar, P. and Singh, S. 1993. Effect of GA_3 and ethrel on ripening and quality of mango cv. Amrapali. *The Horticultural Journal* **6**(1): 19-24.

Monselise, S.P. 1977. Citrus fruit development: Endogenous systems and external regulation. *Proceedings International Society of Citriculture* **2**: 666-664.

Nath, J.C. and Baruah, K. 2000. Effect of pruning and growth regulators on the quality of Assam lemon (*Citrus lemon* Burn*). The Horticultural Journal* **13**(1): 47-45.

Nir, I., Goren, R. and Leshem, B. 1972. Effect of water stress, gibberellic acid and 2-chloroethyl trimethylammonium chloride (CCC) on flower differentiation in Eureka lemon trees. *Journal of the American Society for Horticultural Science* **9**: 774- 778.

Parthiban, S., Saraswathy, S., Indra, N., Samundeeswari, A.V., Rani, B.U and Selvarajan, M. 2010. Problems and prospectus of citrus production in India with special reference to acid lime (*Citrus aurantifolia* Swingle) cultivation in Karnataka. Proceeding of National Seminar on "Citrus Biodiversity for livelihood and Nutritional Security", October 4-5, 2010, NRC, Citrus, Nagpur, Maharashtra. pp.344 – 349.

Saraswathi, T., Rangasamy, P. and Azhakiamanavdan, R. S. 2002. Effect of pre-harvest spray of growth regulators on fruit retention ad quality of mandarins. *(Citrus reticulata). South Indian Horticulture* **51**(1- 6): 110 - 112.

Sharma, A.K., Singh, K. and Mishra, S.P. 2003. Effect of foliar spray of zinc sulphate, 2, 4, 5-T and GA3 on quality of kagzi lime *(Citrus aurantfolia* Swingle). *The Orissa Journal of Horticulture* **31**(2): 29 - 32.

Shrestha, R.L., Dhakal, D.D., Gautam, D.M and Paudyal, K.P. 2012. Variation of Physiochemical components of acid lime (*Citrus aurentifolia* Swingle) fruits at different sides of the tree in Nepal. *American Journal of Plant Sciences* **3**: 1688 – 1692.

Shreshtha, T.N. 1988. Studies on chemical control of flowering and fruiting in acid lime (*Citrus aurentifolia* Swingle). Ph.D. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Singh, A.R and Lal, M. 1982. Performance of citrus fruits in the north genetic plains. *Punjab Horticultural Journal* **22**(1/2): 29-34.

Singh, S.P., Singh, I.B. and Singh, V.N. 1987. A note on effect of gibberellic acid on fruit rotting, fruit retention and quality of jujube (Zizyphus mauritiana Lamk) cv. Banarasi Karaka. *Progressive Horticulture* **19**(1-2): 61-64.

Thirugnanavel, A., Amutha, R., BabyRani, W., Indira, K., Mareeswari, P., Muthulaksmi, S. and Parthiban, S. 2007. Studies on regulation of flowering in acid lime *(Citrus aurantifolia* swingle). *Research Journal of Agriculture and Biological Sciences* **3**(4): 239 - 241.