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EFFECTS OF GA_3 AND SHOOT PRUNING ON FLOWERING AND YIELD IN ASSAM LEMON (*CITRUS LIMON* BURM. F.)

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Abstract

Effect of GA_3 and pruning on flowering and yield in Assam lemon (*Citrus limon* Burm. F.) were studied. Ten treatments were imposed for two seasons (summer and winter) in which significant among the treatments were found for profuse flowering and its yield. Among the different treatments, the pooled data of two seasons showed that G_1P_1 (GA_3 50 ppm single spray plus 15 cm shoot pruning) recorded the highest flower per branch (29.75.), fruitlets per branch (6.4) and yield (10.45 t/ha) as compared to the control plants 26.5 flowers per branch, 5.8 fruitlets per branch and 9.43 mt/ha, respectively. Therefore, combination of GA_3 50 ppm single spray + 15 cm shoot pruning is most promising which can be recommended for improvement of yield in lemon cv. Assam lemon.

Introduction

Assam lemon (*Citrus limon* Burm. F. Family: Rutaceae) a principle lemon cultivar of North Eastern Region of India, have originated in the Eastern Himalayan region and its adjoining areas specially Indo-Burma regions are considered as host of diverse *Citrus* species (Singh and Singh 2006). Lemon is popularly grown in kitchen gardens. In India, fresh lemons are primarily consumed for a cooling effect in summers. It is widely used in preparation of soft drinks and possesses special dietary and medicinal value associated with its high vitamin C content and also used as natural herbal shampoo by boiling its fruit peel and fresh leaves along rice water (Singh *et al.* 2014). Lemon oil is the most important citrus oils used for flavouring soft drinks, baked foods, confectioneries, etc. Besides, it is also used for preparing pickles, squashes, jams, jellies, and marmalades. The plant is endowed with the trait of bearing fruits in several flushes, thus making it available throughout the year (Savreet 2013). The distribution of Assam lemon in North East India includes Assam, Arunachal Pradesh, Nagaland, Meghalaya and Mizoram (Singh and Singh 2006). In India, limes and lemons collectively occupy an area of 2.86 lakh hectare with an annual production of 28.35 lakh ton and having a productivity of 9.9 t/ha. (Anon. 2015). Under tropical conditions limes, lemon and citron flower are available almost throughout the year, whilst spring (February - March) is the main blooming period (Bhattacharya and Dutta 1956). However, in Assam and subtropical condition of Arunachal Pradesh including East Siang district most of the lemons flower round the year but its main peak flowering time is during January-February for summer season fruit and September-October for winter season fruit. Due to continuous flowering and fruiting throughout the year the fruits are of smaller in size, uneven shape and of poor quality. Additionally it is labor intensive with increase in periodical harvest.

Flowering in citrus can be regulated by adopting various horticulture practices like girdling, ringing, pruning, application of plant growth regulators as well as crop regulation practices for production of high yield superior quality fruits of desired season. Crop regulation, the most

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economical flower regulation practice is not feasible in this region due to prolonged rainfall which coincides flushing of crop. Thus pruning and growth regulators are the best alternative to do the same. However, pruning is confined to periodical removal of dead, diseased, water sprouts, criss-cross and weak branches. There is an imperative need for improvement of fruit quality in order to meet the change in market demand and making it available to the maximum extent by foliar spray of GA_3 and regular current season shoot pruning. The effect of GA_3 and pruning in Assam lemon is aimed at more new shoot formation by pruning since it bears fruit in new current shoot maximum up to 30 cm length and improving fruit quality by pruning half of it. Besides, GA_3 will help in improving of fruit quality. Keeping these in view, present study was undertaken to study the **e**ffect of GA_3 and pruning on flowering and yield in Assam lemon under the Pasighat condition of Arunachal Pradesh, India.

Materials and Methods

The present investigations were carried out on 5 years old tree of uniform size at the Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh during the year 2014 - 2015 to evaluate the effect of GA_3 and pruning for the improvement of yield in Assam lemon. The experiment was laid out in 5 × 2 Factorial Randomized Block Design consisting five replications, ten treatments with 1 plant in each treatment. The plants were planted at spacing of 3 × 3 m. The average altitude of the sites of the experiment were about 155 m MSL situated geographically between the coordinates of 28° 04'43" N latitude and 95° 19' 26" E longitude with an altitude of 153 m above the mean sea level. The soil type is sandy loam with a pH of 5.2 and represents a typical subtropical zone with short cool, dry and windy winter, a hot summer and a heavy monsoon season. Study site represents a subtropical, hot and humid climate; in the lower valleys, summer temperatures in June, July and August typically rise to about 30°C, while winter temperatures in December, January and February usually drops to 13°C. Annual rainfall in the state averages about 130 inches (3,300 mm), mostly between April and September.

The experimental materials for the present study comprised of GA_3 at 5 levels resembling 50 ppm single spray, 50 ppm double spray, 100 ppm single spray, 100 ppm double spray and devoid of GA_3, in company with Pruning at 2 levels resembling 15 cm shoot pruning and without pruning. Pruning was carried out during the first week of January and August before the flowering started. Spraying was carried out after the pruning of shoot and for double spray repeated 15 days of first one. The details of the treatments were GA_3 @ 50 ppm (single spray) + 15 cm shoot pruning, GA_3 @ 50 ppm (single spray) + no pruning, GA_3 @ 100 ppm (single spray) + 15 cm shoot pruning, GA_3 @ 100 ppm (single spray) + no pruning, GA_3 @ 50 ppm (double spray) + 15 cm shoot pruning, GA_3 @ 50 ppm (double spray) + no pruning, GA_3 @ 100 ppm (double spray) + 15 cm shoot pruning, GA_3 @ 100 ppm (double spray) + no pruning, no GA_3 + 15 cm shoot pruning and control (No GA_3 + No pruning). Every treated plant was supplemented with 100:100:100g N: P: K/plant/year in two split doses in February-March and October-November before the flowering. The statistical analysis of the data on the mean values of individual characters was made using M Stat software.

Results and Discussion

Application of GA_3 spray and pruning of the current season shoot had a significant influence on number of flowers per branch as well as number of fruitlets per branch after the imposition of the treatments. The pooled data indicated that the highest number (31.35) of flowers per branch and fruitlets (6.90) per branch were obtained in G_1P_1 i.e. (GA_3 50 ppm single spray + 15 cm shoot

pruning of the current season) whereas in control no GA_3 and unpruned were evident low both in flowers per branch and fruitlet per branch. Thirugnanavel *et al.* (2007) also reported that the application of GA_3 increase flower per shoot, initial fruit set apart from delay in flowering in acid lime and Cassiano e*t al*. (2014) also reported the similar finding in acid lime cv. Tahiti lime. Similar findings of improvement in flushing under different pruning regimes were also observed in Kagzi lime (Khan and Syamal 2004). The pruning of the new current season shoot helped adequate accumulation of food reserves which in turn increased the number of flower. As suggested by Lord and Eckard (1987) negative correlation exists between shoot length and flowering in citrus, thus shorter stem perhaps increased the flowers that certainly affect fruitlets. Gorriz *et al*. (2014) also reported that mechanical pruned tree lower the yield due to less vegetative but the fruit diameter and yield increased as compared to control (Table 1).

The pooled data of summer and winter seasons on fruitlet per branch interaction of factors also had a significant effect on number of fruitlets where G_3P_1 i.e. (GA_3 50 ppm double spray plus 15 cm shoot pruning) recorded the highest fruitlets (6.95) which was at par with G_1P_1 (6.9) which was significant over the control (Table 2). Pruning might have played an important role in flowering apart from GA_3 which could be due to the fact that the growth of new shoots was more as compared to unpruned plants consequently more flowering due to more new flush. The results are in line with the findings of Nath and Baruah (2001) in Assam lemon.

Table 1. Effect of GA_3 and pruning on number of flowers per branch of both the seasons.

Factors	G_1	G_2	G_3	G_4	G_0	Mean (P)
P_1	31.35	28.05	29.60	28.10	27.80	28.98
P_0	28.15	24.00	27.55	22.55	25.25	25.50
Mean (G)	29.75	26.03	28.58	25.33	26.53	
		S.Em ±	C.D. 5%			
Effect of GA_3 (G)		0.58	1.65.			
Effect of pruning (P)		0.36	1.05			
S × M interaction		0.82	N.S.			

Table 2. Effect of GA_3 and pruning on number of fruitlets per branch of both the seasons.

Factors	G_1	G_2	G_3	G_4	G_0	Mean (P)
P_1	6.90	6.05	6.95	6.25	6.10	6.45
P_0	5.90	4.95	5.55	4.85	5.50	5.35
Mean (G)	6.40	5.50	6.25	5.55	5.80	
		S.Em±	C.D. 5%			
Effect of GA_3 (G)		0.16	0.47			
Effect of pruning (P)		0.08	0.23			
S × M interaction		0.21	0.62			

The parameter of number of fruits per tree at harvest stage was also found to be significant after the imposition of pruning but non-significant in GA_3 application and it combined interaction factors of GA_3 and pruning (Fig. 1). The highest number of fruits per tree at harvest stage was

found in G_4P_1 followed by G_0P_1 and G_1P_1, respectively (Table 3). However, the highest fruit yield of both seasons was obtained in G_1P_1 (10.19 t) whereas G_0P_0 reported lowest (8.2 mt/ha). This might be due to enhanced vegetative growth by the GA_3 spray which in turn directed improvement in carbohydrate metabolism. Lakshmi *et al*. (2014) also reported that increase in yield and yield components of acid lime by GA_3 spray attributed to synthesis of chlorophyll from source to sink. Savreet (2013) reported that the foliar spray of NAA (10, 20 and 40 ppm) and GA_3 (5, 10 and 20) applied twice at interval of 15 days during the month of May proved for managing fruit cracking and improving fruit quality. Ngugen and Yen (2013) also reported that spraying with 30 ppm GA_3 gave the faster rate of fruit growth, fruit set, fruit size, fruit weight and also reduced the fruit drop.

Table 3. Effect of GA_3 and pruning on number of fruits at harvest stage of both the seasons.

Factors	G_1	G_2	G_3	G_4	G_0	Mean(P)
P_1	84.00	80.80	81.80	86.80	85.20	83.72
P_0	79.00	77.20	76.00	78.80	83.80	78.96
Mean (G)	81.50	79.00	78.90	82.80	84.50	
		S.Em±	C.D. 5%			
Effect of GA_3 (G)		2.96	N.S.			
Effect of pruning (P)		1.23	3.54			
S × M interaction		3.76	N.S.			

Imposition of GA_3 sprays and shoot pruning treatments significantly improved yield parameters (Table 4). The pooled data of both the seasons revealed that the highest fruit yield per tree was recorded in G_1P_1 (10.19 kg/tree) as against the control (8.2 kg/tree). The improvement in yield after the imposition of GA_3 spray and shoot pruning might be due to reduction in number of flowering sites. Conversely it increased the flowering sites in the upcoming season resulting higher yield (Iwagaki and Hirose 1977). Nath and Baruah (1999) also reported that combination of pruning and GA_3 spray enhanced in fruit yield in Assam lemon. Further, the findings of present investigation are also in agreement with results reported by Gorriz *et al*. (2014).

Table 4. Effect of GA_3 and pruning on pooled yield (kg) per tree of both the seasons.

Factors	G_1	G_2	G_3	G_4	G_0	Mean (P)
P_1	10.19	9.58	9.97	9.84	9.37	9.79
P_0	8.54	8.39	8.48	8.48	8.20	8.37
Mean (G)	10.40	9.98	10.10	10.17	9.75	
		S.Em±	C.D. 5%			
Effect of GA_3 (G)		0.10	0.29			
Effect of pruning (P)		0.05	0.17			
S × M interaction		0.13	0.38			

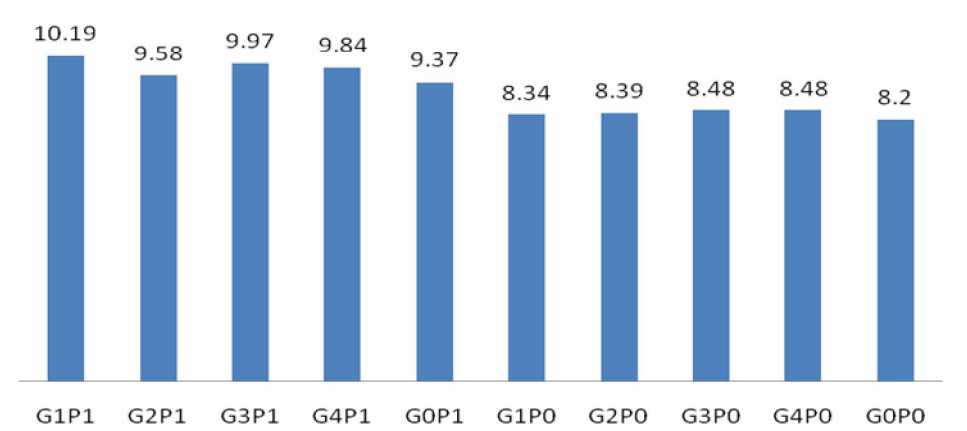

Fig. 1. Effect of GA_3 and pruning on yield/tree/year in lemon cv. Assam lemon.

From the experiment, it may be concluded that in Assam lemon there are two flushes in a year and if there is no regular pruning it is difficult for intercultural operation and maintenance of space as well as it reduces the fruit quality due to fruiting throughout the year. Therefore, combination of GA_3 50 ppm (single spray) +15 cm shoot pruning can be recommended to the citrus growers of Assam lemon to increase the yield and productivity for the foothills condition of Arunachal Pradesh.

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