

Original Research Article

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Effect of Different PGR and Urea on Fruit Drop and Yield of Assam Lemon [*Citrus limon* (L.) Burm.]

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ABSTRACT

The synthetic PGR like 2,4-D and NAA along with 1% urea were investigated on 7 years old trees of lemon cv. Assam Lemon planted with a spacing of 3x3m at the Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Pasighat, Arunachal Pradesh. The results of the pooled data of winter and summer seasons revealed that the imposition of different treatments had a significant effect on reducing fruit drop and improving the yield of fruits. Among the different treatments, T₆ (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea) was found to be most effective with maximum number of fruits/plant at harvesting stage (67.6), yield/plant (8.29 kg) and minimum fruit drop (13.91 %) as compared to control (33.15% fruit drop and yield 4.14kg/plant). However, non-significant effect was found in plant height and canopy spread. Hence, the combination of recommended dose of fertilizers 100:100:100g NPK/plant/year along with 20 kg FYM and synthetic PGR NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea foliar spray twice (after fruit setting and fully developed stage) were found to be efficient for increasing yield and productivity in Assam Lemon which can be recommended for reducing fruit drop of this main cultivar lemon for the North East region in the future.

Keywords

NAA, 2,4-D, Urea,
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Introduction

Assam Lemon [*Citrus limon* (L.) Burm.] is the important lemon cultivar of the North Eastern region of India. It belongs to the family Rutaceae and is originated in Assam. The cultivar is also known as Pat Nimboo in Western India, Seville Lemon in Andhra Pradesh and Nepali Oblong in some parts of the country (Chattopadhyay, 2007). It possesses a wide variety of culinary, industrial, dietary and medicinal uses

associated with its high vitamin C content. In India, fresh lemon is primarily used in the preparation of soft drinks for imparting cooling effect in summer. It is also used for preparing pickles, squashes, jams, jellies and marmalades. Lemon essential oil is used for flavouring soft drinks, baked foods, confectioneries, etc. and also as a key ingredient in cosmetic industries. Leaves are used in tea and for preparing meat and seafood. Singh *et al.*, (2014) mentioned the use of its fresh leaves and peel in the

preparation of a natural herbal shampoo by boiling with rice water. Besides, insecticidal properties of lemon peel extract have also been reported (Su and Horvat, 1982). The cultivation of this fruit is gaining popularity because of its large crop holding capacity, big size fruits and abundant juice content (Randhawa and Srivastava, 1986). Fruits are available throughout the year since it blooms continuously, though the spring bloom is the heaviest (Devi *et al.*, 2011). Unfortunately, fruit drop has become a limiting factor for obtaining increased fruit production in citrus. It occurs at various stages of fruit development due to malnutrition (Ashraf *et al.*, 2012), fungal attack (Lima *et al.*, 2011) and hormonal imbalance (Khan *et al.*, 2014; Agustí *et al.*, 2006). Fruit drop is influenced by an abscission mechanism, which is held under check by a chain of physiological processes (Randhawa and Srivastava, 1986). Assam Lemon is facing fruit drop mainly after fruit setting and pre-mature fruit drop. However, there is no report for the control of pre mature fruit drop by the use of synthetic PGR for this important lemon variety of North East India. Keeping in view the above consideration, the present study was planned with the objectives to study the effect of different growth regulators and urea in controlling pre- harvest fruit drop and to increase yield and productivity of this fruit crop.

Materials and Methods

The present investigation was carried out during the year 2017 at Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh which is geographically located at 28° 04' 43" N latitude and 95° 19' 26" E longitude with an altitude of 153 m above mean sea level. Seven (7) years old Assam Lemon trees planted at a spacing of 3m x 3m were used as experimental materials and the experiment was laid out in

Randomized Block Design (RBD) consisting of 9 (nine) treatments and 5 (five) replications with one plant in each treatment. The details of the treatments are T₁ (NAA @ 10 ppm + 1% urea), T₂ (2,4-D @ 10 ppm + 1% urea), T₃ (NAA @ 20 ppm + 1% urea), T₄ (2,4-D @ 20 ppm + 1% urea), T₅ (NAA @ 10 ppm + 2,4-D @ 10 ppm + 1% urea), T₆ (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea), T₇ (NAA @ 10 ppm + 2,4-D @ 10 ppm), T₈ (NAA @ 20 ppm + 2,4-D @ 20 ppm) and T₉ (Control). The recommended dose of fertilizer (RDF) 100:100:100 g NPK/plant/year with 20 Kg FYM was applied to all the plants under study before flowering (half dose during January and the remaining half during August). Two synthetic auxins *viz.*, 2,4-dichlorophenoxy acetic acid (2,4-D) and Naphthalene acetic acid (NAA) @ 10 ppm and 20 ppm were applied as foliar spray to the plants. Since they are insoluble in water, 2,4-D and NAA were initially dissolved in a small amount of 70-80% ethanol and 1 N sodium hydroxide (NaOH) respectively and then brought to the required volume with water for preparation of spray solutions. 1% diluted urea solution was applied to the plants as foliar spray.

To record the fruit drop % tagging of fruits was done after fruit setting and prior to treatment application. 40 fruits /plant in summer season crop and 20 fruits/plant in winter season crop were tagged randomly on four directions (North, South, East and West) of the plant for the observation of fruit drop %. During winter there is less fruits as compared to summer season fruits so only 20 fruits/plant tagging was done during winter season. First foliar spray of PGR (2,4-D and NAA @ 10ppm and 20ppm) and urea (1%) was applied after fruit setting and the second spray was applied at fully developed stage of fruits. Number of the tagged fruits retained on the plant was counted three weeks after application of treatment and thereafter every month till harvesting of the fruits. Observations recorded during field experiment

were subjected to the statistical analysis of variance for RBD. The statistical analysis of the data on the mean values of individual characters was analyzed using M State software. Significance and non-significance of the variance due to different treatments was determined by calculating the respective 'F' values according to the method described by Gomez and Gomez (2010).

Results and Discussion

Effect of PGR and urea on vegetative growth parameters

Plant height was found to be non-significant to the application of PGR and urea (Table 1). However, maximum increase in plant height was observed in T₆ (12.50 cm) and minimum was observed in control (8.75 cm). The effect of the treatments was found to be non-significant on canopy spread in North-South direction (Table 1). However, highest increase in canopy spread (N-S) was found in T₆ (12.25 cm) and lowest was recorded in control (9.50 cm). The treatments were also found to have a non-significant effect on canopy spread in East-West direction (Table 1). However, highest increase in canopy spread (E-W) was recorded in T₆ (11.73 cm) and lowest was observed in control (9.25 cm). Similarly, Prasad *et al.*, (2015) reported that in Kinnow Mandarin the plant growth regulators when applied in combination with urea were more effective in enhancing the vegetative growth of the plant rather than the application of PGRs alone. The role of urea in promoting plant growth may be attributed to nitrogen being a key elemental component of chlorophyll, the compound by which plants absorb sunlight energy to convert atmospheric carbon dioxide to carbohydrates through photosynthesis. Carbohydrates thus produced provide energy for plant growth and development. Increase in plant growth with foliar application of urea. Besides, Singh *et al.*, (2017a) also reported similar effect of PGR in the vegetative growth in guava.

Effect of PGR and urea on fruit drop % and yield attributing parameters

The effect of different treatments on the number of fruits/plant at harvesting stage was found to be highly significant (Table 2). Number of fruits/plant during summer season was comparatively more than that in the winter season apparently due to profuse flowering during summer season crop. In both the seasons, T₆ was found to be the best treatment with 96.80 fruits/plant in summer season crop and 38.40 fruits/plant in winter season crop. Consequently, in the pool data, maximum number of fruits was recorded in treatment T₆ (67.60) which is at par with T₅ (64.40) and lowest was recorded in control plants (37.90). Due to higher flowering tendency during summer in comparison to winter season crop, fruit yield per plant was higher in summer (12.58 kg) than the winter crop (4.00 kg) which was observed in T₆.

Pool data for this character inevitably recorded highest value in treatment T₆ (8.29 kg) which is at par with T₅ (7.78 kg) and lowest yield was recorded in control plants (4.14 kg) in which lowest fruit drop percentage was recorded in treatment T₆ (13.91 %) which is at par with T₅ (14.24 %), T₈ (17.31 %) and T₇ (19.46 %) and the highest fruit drop percentage was observed in control plants (33.15 %). Abscission of fruit is largely associated with the balance between auxin and ethylene that controls the cell separation processes (Khan *et al.*, 2014). The dependence of abscission relative to the endogenous content of auxins has been proven by exogenous application of 2,4-D or NAA, as the transportation of auxins by the plant lasts for a long time without ethylene appearing to affect it (Suman *et al.*, 2017). Reduction in fruit drop percentage may be due to the action of auxin in strengthening the cells in the abscission zone which is localised at the peduncle (Stewart and Hield, 1950) (Fig. 1–4 and Table 3).

Table.1 Effect of PGR and urea on plant height and canopy spread (N-S and E-W directions) of lemon cv. Assam Lemon

Treatments	Increase in plant height (cm)			Increase in canopy spread (North- South) (cm)			Increase in canopy spread (East- West) (cm)		
	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool
T ₁	11.00	10.00	10.50	11.00	9.50	10.25	10.00	10.50	10.25
T ₂	11.00	10.50	10.75	11.00	10.00	10.50	10.00	11.00	10.50
T ₃	11.50	11.00	11.25	11.00	11.00	11.00	11.00	10.20	10.60
T ₄	12.50	11.00	11.75	11.50	11.00	11.25	11.20	10.80	11.00
T ₅	12.00	11.50	11.75	12.74	11.00	11.87	11.20	11.75	11.47
T ₆	12.70	12.30	12.50	12.60	11.90	12.25	11.86	11.60	11.73
T ₇	11.00	9.00	10.00	10.00	9.50	9.75	9.50	10.00	9.75
T ₈	9.50	9.50	9.50	10.50	9.00	9.75	9.50	9.50	9.50
T ₉	8.50	9.00	8.75	10.00	9.00	9.50	9.00	9.50	9.25
SEm±	1.44	1.37	1.07	0.90	1.39	0.79	1.20	0.90	0.60
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table.2 Effect of PGR and urea on fruit drop % and yield attributing parameters of lemon cv. Assam lemon

Treat-ments	Number of fruits/plant after fruit set			Number of fruits/plant at harvesting stage			Fruit drop (%)			Yield (Kg/Plant)		
	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool
T ₁	89.60	33.4	61.50	63.00	22.20	42.60	29.50	24.17	26.83	7.67	1.72	4.69
T ₂	90.80	35.00	62.90	64.40	21.00	42.70	28.00	24.43	26.22	7.92	1.72	4.82
T ₃	90.80	34.60	62.70	64.60	23.20	43.90	27.50	22.40	24.95	8.17	2.05	5.10
T ₄	96.00	37.60	66.80	70.80	25.80	48.30	25.28	18.13	21.71	9.10	2.40	5.75
T ₅	108.80	42.20	75.50	92.00	36.80	64.40	14.50	13.98	14.24	11.88	3.67	7.78
T ₆	109.00	41.20	75.10	96.80	38.40	67.60	14.21	13.62	13.91	12.58	4.00	8.29
T ₇	97.80	38.80	68.30	73.20	35.60	54.40	22.06	16.86	19.46	9.44	3.56	6.49
T ₈	109.80	40.80	75.30	89.60	36.00	62.80	18.28	16.33	17.31	11.62	3.79	7.71
T ₉	90.00	34.00	62.00	57.40	18.40	37.90	35.01	31.28	33.15	6.93	1.36	4.14
SEm ±	10.95	4.81	5.96	6.89	5.29	5.05	4.14	3.89	2.73	0.91	0.61	0.65
CD (5%)	NS	NS	NS	19.84	15.25	14.56	11.93	11.21	7.88	2.62	1.75	1.88

Table.3 Effect of PGR and urea on harvesting period and physical parameter of lemon cv. Assam Lemon

Treat-ments	Harvesting period (Number of days)			Fruit length (cm)			Fruit diameter (cm)			Fruit fresh weight (g)		
	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool
T ₁	101.00	98.00	99.50	8.54	6.96	7.75	5.04	4.69	4.86	121.54	76.47	99.00
T ₂	97.00	98.00	97.50	8.57	7.40	7.98	5.07	4.65	4.86	123.02	79.80	101.41
T ₃	97.00	98.00	97.50	8.58	7.48	8.03	5.10	4.78	4.94	126.40	84.93	105.66
T ₄	97.00	99.00	98.00	8.70	7.69	8.20	5.19	4.78	4.98	128.21	87.03	107.62
T ₅	103.00	100.00	101.50	9.00	7.98	8.49	5.34	5.27	5.30	130.52	102.59	116.56
T ₆	99.00	100.00	99.50	9.60	8.10	8.84	5.40	5.34	5.36	132.24	105.12	118.68
T ₇	99.00	98.00	98.50	8.75	7.82	8.28	5.24	4.84	5.04	129.03	95.98	112.52
T ₈	99.00	99.00	99.00	8.78	7.85	8.31	5.30	4.96	5.13	129.47	99.62	114.54
T ₉	99.00	98.00	98.50	8.44	6.64	7.54	5.01	4.26	4.63	118.46	73.74	96.10
SEm ±	2.13	1.43	1.33	0.23	0.30	0.20	0.09	0.21	0.12	2.17	6.20	3.52
CD (5%)	NS	NS	NS	0.66	0.86	0.57	0.27	0.62	0.35	6.24	17.87	10.14



Fig.1 Flowering and fruit setting period



Fig.2 Tagging of the fruiting branches



Fig.3 Pre-harvest drop



Fig.4 Heavy bearing after spraying of PGR and urea

Similar findings were concurred by Almeida *et al.*, (2004) and Nawaz *et al.*, (2008) where the application of 2, 4-D and NAA reduced the natural fall rate when compared to control. Modise *et al.*, (2009) also concluded that the application of 2,4-D @ 20 ppm significantly reduced fruit drop by more than 50% in sweet orange. Further, studies in Satsuma Mandarin revealed that application of 2,4-D and NAA

significantly reduced pre harvest drop as compared to control (Amiri *et al.*, 2012). In the present investigation, it was observed that NAA and 2,4-D when applied in combination with 1% urea gave superior effect in reducing fruit drop. This may be due to the enhancement in vegetative growth leading to the production of more photosynthates. This finding is in conformity with Singh *et al.*,

(2017b) who reported that foliar application of urea (1%) + 2, 4-D (15 ppm) can be used to control fruit drop in Khasi Mandarin.

The increase in yield/plant and number of fruits/plant may be attributed to the reduction in fruit drop under the effect of plant growth regulators and urea. Bhatt *et al.*, (2016) also recorded maximum number of fruits per plant in Pant Lemon-1 @ 10 ppm NAA foliar application. The effect of PGR and urea foliar spray has no significant influence different treatments on the parameter harvesting period. However, longest harvesting period was observed in treatment T₅ (101.50 days) followed by T₆ and T₁ (99.50 days) and shortest harvesting period was recorded in T₄ (98.00 days). The effect of different treatments on fruit length was found to be highly significant in which maximum fruit length was recorded in treatment T₆ (8.84 cm) which is at par with T₅ (8.49 cm), T₈ (8.31 cm) and T₇ (8.28 cm) and minimum was observed in control plants (7.54 cm). Similarly the treatment has significant effect on fruit diameter also in which maximum fruit diameter was recorded in treatment T₆ (5.36 cm) which is at par with T₅ (5.30 cm), T₈ (5.13 cm) and T₇ (5.04 cm) and minimum fruit diameter was found in control plants (4.63 cm). As a result of significant effect on fruit length and breadth by PGR and urea foliar spray resulting maximum fresh weight of the fruit was observed in treatment T₆ (118.68 g) which is at par with T₅ (116.56 g), T₈ (114.54 g) and T₇ (112.52 g) and the minimum fresh weight was found in control plants (96.10 g).

The improvement in overall physical characters (fruit length, breadth and fruit weight) of the fruit may be due to the contribution of auxin in fruit development which is based on a greater cell expansion. This expansion is probably due to an increase in cell vacuolisation that, in turn, increases

vesicle size, locule dimensions and final fruit size (El-Otmani *et al.*, 1993; Guardiola and Lazaro, 1987).

These findings are in concordance with the results of Verma *et al.*, (2018) also revealed that 2% urea spray along with PGR increased the fruit weight of Nagpur Mandarin. Therefore, the combination of recommended dose of fertilizers 100:100:100g NPK/plant/year along with 20 Kg FYM and synthetic PGR NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea foliar spray twice (after fruit setting and fully developed stage) were found to be efficient for increasing yield and productivity in Assam Lemon which can be recommended to reduced the fruit drops which is a major physiological disorder which hamper the yield of this important lemon cultivar in North East India.

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