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EFFECTS OF FOLIAR SPRAY OF NAA, 2,4-D AND UREA ON FRUIT YIELD AND QUALITY OF *CITRUS LIMON* (L.) BURM. CV. ASSAM LEMON

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Abstract

Effects of foliar spray of NAA, 2, 4-D and urea on fruit yield and quality of *Citrus limon* (L.) Burm. cv. Assam lemon was studied. Nine treatments were imposed in RBD for two seasons (summer and winter). Among the treatments in T_6 (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea) the maximum pulp content (81.58 g/fruit), juice content (40.47 ml/fruit), reducing sugar (0.51%) and ascorbic acid (48.56 mg/100 g) were recorded. Whereas, maximum TSS (9.88%), total sugar (1.66%) with minimum titratable acidity (3.10%) was recorded in treatment T_5 (NAA @ 10 ppm + 2,4-D @ 10 ppm + 1% urea). Hence, the combination of recommended dose of fertilizers 100 : 100 : 100 g NPK/plant/year along with 20 kg FYM and NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea foliar spray twice (after fruit setting and fully developed stage) may be recommended for improvement of yield and quality of this main cultivar lemon for the North East region of India in the future.

Assam lemon [*Citrus limon* (L.) Burm.] is a notable lemon seedless cultivar mainly grown in homestead gardens. It is a medium size evergreen tree with vigorous growth, upright spreading with irregular crown growth and is comparatively thorny with short and slender spines. Flowers are purple tinged, large and occur in clusters. Fruits are long elliptic to oblong-ovate in shape. It is commercially cultivated by stem cutting due to its seedless nature having 1 - 2 non-viable seeds/fruit. The distribution of lemon in North-Eastern India includes Assam, Arunachal Pradesh, Nagaland and Meghalaya (Sharma *et al.* 2004). It possesses a wide variety of culinary, industrial, dietary and medicinal properties. Fresh lemon is primarily used in the preparation of soft drinks. It is also used for preparing pickles, squashes, jams, jellies and marmalades. Lemon essential oil is a key ingredient in cosmetic industries besides using for flavouring soft drinks, baked foods, confectioneries, etc. (Chattopadhyay 2007). Assam Lemon produces two distinct flowering flushes in a year *viz.*, spring (February - March) and autumn (September - October), though the spring bloom is the heaviest. Since the plant is endowed with the trait of bearing fruits in several flushes, the fruit is available throughout the year (Mahesha and Singh 2018). However, the fruit quality is deteriorated due to its continuous bearing nature without any resting period and premature fruit also occurs which hamper the yield of the crop (Mahesha 2016). Similar findings are documented by Bhatt *et al*. (2016) in which the maximum number of fruits (403.27) per plant and maximum pulp: seed ratio (20.89) was recorded under NAA (10 ppm) foliar application in lemon cv. Pant Lemon-1. Sandhu (2013) also reported that NAA at 40 ppm of 15 days interval during the month of May proved to be the best treatment for managing fruit cracking and improving fruit quality in lemon. Further, Singh *et al*. (2017) reported that the combination of recommended dose of fertilizer along with Urea (1%) + 2,4-D (15 ppm) foliar spray thrice during April, July and September control fruit drop in Khasi mandarin with maximum fruit retention (45.4%) and

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increase yield. Keeping these in view, the present study was undertaken to study the **e**ffect of different concentrations of synthetic auxin (2,4-D and NAA) along with 1% urea for fruit retention at mature stage, yield and quality of lemon cv. Assam Lemon.

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, India. Seven years old lemon cv. Assam Lemon trees planted at a spacing of 3 m × 3 m were used as experimental materials having uniform average plant height 2.00 m and tree volume 6.50 m^3 as test plant for the experiment. The experiment was laid out in RBD consisting of nine treatments and five replications with one plant in each treatment. The treatments applied were: T_1 (NAA @ 10 ppm + 1% urea), T_2 (2,4-D @ 10 ppm + 1% urea), T_3 (NAA @ 20 ppm + 1% urea), T_4 (2,4-D @ 20 ppm + 1% urea), T_5 (NAA @ 10 ppm + 2,4-D @ 10 ppm + 1% urea), T_6 (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea), T_7 (NAA @ 10 ppm + 2,4-D @ 10 ppm), T_8 (NAA @ 20 ppm + 2,4-D @ 20 ppm) and T_9 (dist. water-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 PGR *viz.*, 2,4-D and NAA @ 10 and 20 ppm were applied as foliar spray to the plants along with 1% urea solution. The water insoluble PGRs were initially dissolved in small quantity of ethanol (NAA) or 1N NaOH (2,4-D) and all spray solutions were prepared in distilled water separately and make up the volume of required quantity with tap water. PGR *viz.*, NAA and 2,4-D were applied on the same day separately having the pH 5.5 (slight acidic) and 8.5 (slight alkaline), respectively and the 1% urea was applied 7 - 10 days prior to its application @ 500ml/tree for each solution with knap-sack sprayer without any adhesive chemical to the foliar spray. First foliar spray of PGR (2,4-D and NAA @ 10 and 20 ppm) and urea (1%) was applied two weeks after fruit setting and the second spray was applied at fully developed stage of fruits. The fruits were harvested when they are fully matured and start to develop attractive green colour. Chemical quality characters like TSS (%), tritatable acidity (%), total sugar (%), reducing sugar (%) and ascorbic acid (mg/100 g) were measured as per standard procedures of AOAC (1990) using 10 fruits randomly selected from each treatments and the observations recorded were subjected to the statistical analysis of variance for RBD. Significance and non-significance of the variance due to different treatments were determined by calculating the respective F values according to the method described by Gomez and Gomez (2010).

All the physical parameters except peel thickness were found to be significantly influenced by the different treatments of auxin (2,4-D and NAA) and 1% urea. Maximum fruit fresh weight (118.68 g), pulp content (81.58 g) and juice content (40.47 ml) were recorded in treatment T_6 (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea) while the minimum fruit fresh weight (96.10 g), pulp content (60.62 g) and juice content (27.65 ml) were recorded in control (Table 1). Though non-significant, highest peel thickness was recorded in treatment T_5 (4.67 mm) and lowest was found in T_4 (4.06 mm). The improvement in overall physical characters 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). These findings are in agreement with the results of Amiri *et al*. (2012) in Satsuma Mandarin. Verma *et al.* (2018) also revealed that 2% urea spray increased the fruit weight of Nagpur Mandarin.

Biochemical analysis of the pooled data (Table 2) of both seasons (summer and winter) revealed that TSS, total sugar, reducing sugar and ascorbic acid were significantly increased by the treatments. T_5 (NAA @ 10 ppm + 2,4-D @ 10 ppm + 1% urea) recorded maximum TSS (9.88%) and total sugar content (1.66%) in comparison to other treatments but was found to be at par with T_6 (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea). On the other hand, the highest values of

Table 1. Effect of foliar spray of 2,4-D, NAA and 1% urea on yield parameters of *Citrus limon* cv. Assam Lemon.

Treatment	Fruit fresh weight (g/fruit)			Peel thickness (g/fruit)			Pulp content (g/fruit)			Juice content (ml/fruit)		
	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool
T_1	121.54	76.47	99.00	4.44	3.93	4.18	77.28	51.35	64.31	32.67	27.43	30.05
T_2	123.02	79.80	101.41	4.68	3.87	4.27	79.28	53.98	66.62	31.73	28.03	29.88
T_3	126.40	84.93	105.66	4.44	4.03	4.23	83.95	57.41	70.68	34.90	30.73	32.81
T_4	128.21	87.03	107.62	4.26	3.87	4.06	85.68	59.77	72.72	35.82	32.88	34.35
T_5	130.52	102.59	116.56	4.94	4.40	4.67	90.11	70.20	80.15	40.43	36.42	38.43
T_6	132.24	105.12	118.68	4.10	4.48	4.29	91.19	71.96	81.58	42.50	38.45	40.47
T_7	129.03	95.98	112.52	4.70	4.20	4.45	87.88	66.31	77.10	37.78	34.40	36.09
T_8	129.47	99.62	114.54	4.44	4.17	4.47	88.70	68.13	78.42	39.57	35.69	37.63
T_9	118.46	73.74	96.10	4.52	4.27	4.39	74.77	46.47	60.62	30.24	25.07	27.65
SEm ±	2.17	6.20	3.52	0.24	0.30	0.16	3.71	4.55	2.58	2.49	3.01	2.09
CD (5%)	6.24	17.87	10.14	NS	NS	NS	10.69	13.11	7.44	7.18	8.69	6.02

Table 2. Effect of foliar spray of 2,4-D, NAA and 1% urea on quality parameters of *Citrus limon* cv. Assam Lemon.

Treatment	TSS (%)			Titratable acidity (%)			Total sugar (%)			Reducing sugar (%)			Ascorbic acid (mg/100 g)		
	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool	Summer	Winter	Pool
T_1	8.58	8.54	8.56	4.27	4.44	4.35	1.51	1.42	1.46	0.38	0.39	0.38	40.06	36.94	38.5
T_2	8.46	8.56	8.51	4.08	4.55	4.31	1.47	1.44	1.46	0.38	0.41	0.39	41.46	37.03	39.25
T_3	9.02	8.80	8.91	3.77	4.35	4.06	1.50	1.49	1.49	0.38	0.44	0.41	42.16	39.44	40.8
T_4	9.00	8.88	8.94	3.85	4.29	4.07	1.54	1.45	1.49	0.40	0.45	0.42	43.78	41.16	42.47
T_5	9.48	10.28	9.88	3.06	3.14	3.10	1.67	1.64	1.66	0.44	0.52	0.48	46.88	47.32	47.1
T_6	9.26	9.42	9.34	3.29	3.40	3.35	1.57	1.59	1.59	0.46	0.57	0.51	48.86	48.26	48.56
T_7	8.88	9.22	9.05	3.46	3.71	3.58	1.56	1.54	1.55	0.40	0.48	0.44	44.18	42.57	43.38
T_8	9.04	8.66	8.85	3.51	3.85	3.68	1.55	1.53	1.54	0.41	0.48	0.44	45.46	44.24	44.85
T_9	8.38	8.32	8.35	4.77	5.06	4.92	1.43	1.38	1.40	0.38	0.37	0.37	38.32	35.8	37.06
SEm ±	0.24	0.39	0.25	0.24	0.37	0.20	0.03	0.05	0.03	0.02	0.04	0.02	1.63	2.17	1.36
CD (5%)	0.70	1.14	0.71	0.70	1.07	0.57	0.08	0.13	0.08	0.05	0.11	0.06	4.69	6.26	3.19

reducing sugar (0.51%) and ascorbic acid content (48.56 mg/100 g) were observed in T_6 (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea) which was at par with T_5 (NAA @ 10 ppm + 2,4-D @ 10 ppm + 1% urea). The results are in agreement with that obtained by Saleem *et al.* (2008) in which various concentrations of NAA and 2,4-D significantly increased TSS, vitamin C and reducing sugar percentage of Kinnow Mandarin. The increase in total soluble solids as a result of auxin and urea spray may be ascribed to fact that application of these growth regulators probably improved the physiology of leaves, thereby causing better translocation of vital components in the fruit and assimilation of photosynthates by the developing fruit (Pandey 1999). The increase in ascorbic acid might be due to catalytic influence of growth regulators on its biosynthesis from glucose-6-phosphates which is thought to be precursor of vitamin C (Patel *et al*. 2017). However, titratable acidity was found to have a decreasing trend in response to the treatments. Minimum titratable acidity (3.10%) was obtained when the plants were treated with T_5 (NAA @ 10 ppm + 2,4-D @ 10 ppm + 1% urea) with at par value with T_6 (NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea). Conversion of organic acids to sugars might be the reason of reduction in titratable acidity (Tuan and Ruey 2013) and increase in total sugar (Mandal *et al*. 2015). This finding is more or less same with the one reported by Nawaz *et al.* (2011) in Kinnow Mandarin.

From the present study, it may be concluded that there are two flushes in Assam Lemon every year and if no regular nutrient management is taken up, it is difficult to maintain the fruit yield and quality due to flowering and fruiting throughout the year. Consequently, application of RDF @ 100:100:100g NPK/plant/year along with 20 kg FYM and NAA @ 20 ppm + 2,4-D @ 20 ppm + 1% urea foliar spray twice (after fruit setting and fully developed stage) can be recommended to the citrus growers of Assam Lemon in order to increase the yield and quality in future.

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