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Effect of Polyamine and Growth Regulators on Yield and Quality of Litchi cv. China

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A B S T R A C T

A field experiment was conducted to study the effects of plantgrowth regulators and polyamine on yield and quality of litchi cv. China at the Experimental Farm-1, Department of Horticulture, SASRD, Nagaland university, Medziphema Campus, Nagaland during the year 2016-2017 and 2017-2018.The trees were sprayed with Gibberellic Acid @ 40 ppm (T_1), Naphthalene Acetic Acid @ 40 ppm (T_2), Putrescine @ 1.0 mM/L (T_3), Gibberellic Acid @ 40 ppm + Putrescine @ 1.0 mM/L (T_4), Naphthalene Acetic Acid @ 40 ppm + Putrescine @ 1.0 mM/L (T_5) and water (control: T_6) at pea and marble stage using Randomized Block Design comprising of four replications. Among the various treatments, minimum fruit drop percentage (54.32% and 51.07%) was observed by spraying with Naphthalene Acetic Acid @ 40 ppm from fruit set to maturity and as a consequences T_2 was found to be effective in increasing the fruit retention (45.68% and 48.93%). T_4 proved to be effective in minimizing fruit cracking (2.30 % and 1%) with highest leaf water content (77.77% and 81.77%) while maximum fruit cracking (7.46% and 4.03%) and lowest leaf water content (70.25 % and 71.81%) was found in control. GA_3 @ 40 ppm (T_1) showed the maximum values of fruit weight with 20.20 g and 21.10 g and aril recovery percentage with 64.36 % and 65.40 % whereas control recorded lowest values of 15.95 g and 16.10 g and 53.48 % and 55.16 % aril respectively. It was also recorded the highest average TSS 17.32ºB, total sugar (10.22 %), ascorbic acid (61.00 mg/100g pulp) and lowest acidity (0.47 %) by spraying of GA_3 @ 40 ppm (T_1). Maximum anthocyanin content (59.76 mg and 59.86 mg per 100 g peel) in peel and protein content (12.69 % and 13.13 %) in pulp was noticed in Naphthalene Acetic Acid @ 40 ppm (T_2) whereas minimum anthocyanin content (40.92 mg and 40.74 mg/100 g peel) in peel and protein content (9.83% and 10.43%) in pulp was recorded in control.

Keywords

Litchi, plant growth regulators, polyamine, yield, quality

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Introduction

Litchi (*Litchi chinensis* Sonn.) is an evergreen subtropical fruit tree and member of sapindaceae family. Litchi is native of South China and it reached in India by the end of 17th century. India is not only the second largest producer of litchi next to China but also Indian litchis are highly acceptable in the global market for its good size and excellent quality. Bihar is the largest producer of litchi in India followed by West Bengal. Plant growth regulators are organic substances (other than nutrients), which in small amount promote, inhibit or otherwise modify any physiological process in plants. Thus the use of plant growth regulators has resulted in some outstanding achievements in several fruit crops with respect to growth, yield and quality.

Polyamines are aliphatic amines of low molecular weight, derived from the decarboxylation of the amino acids arginine and ornithine. Polyamines have been found to increase fruit set and yield in several fruit crops (Crisosto *et al*., 1988; Singh and Singh, 1995), including litchi (Mitra and Sanyal, 1990). The polyamines are also implicated in the regulation of abiotic and biotic stresses, development, and morphogenesis of plants.Massive fruitlet drop usually starts after ending of female bloom and continue for about a month comprising about 90% of fruitlets abscission (Stern *et al*., 1995).

Reduction of fruit drop by application of growth substances was reported by many workers (Khan *et al*., 1976a; Barua and Mohan, 1984a). Many workers have observed that fruit cracking are promoted by high temperature (above 38^0 C) with hot winds, low humidity (below 60 %), low soil moisture resume (above 60 % ASM depletion), hormonal imbalance, deficiency of micronutrients and a varietal character. Fruit cracking occurs mainly after the fruit begin to colour, coinciding with the start of rapid aril growth (Wang *et al.*, 2006).

Fruit cracking and fruit drop in litchi is very common and becomes a great challenge in a given sub-humid and sub-tropical agro climatic condition in Nagaland. Therefore, the exogenous foliar application of growth regulators and some polyamine are very much essential to improve the quality as well as reduce the cracking of fruits and fruit drop in litchi. Reduction in fruit drop with the application of growth substances was reported by many workers (Khan *et al*., 1976b; Barua and Mohan, 1984b). Keeping in view the commercial importance and potential of litchi in Nagaland, the research efforts had been intensified to minimize the incidents of fruit drop,fruit cracking and to get the fruit with superior quality.

Materials and Methods

The experiment was carried out on 25 years old litchi plants being maintained at Horticulture Experimental cum Research Farm, SASRD, Nagaland university, Medziphema campus during the year 2016-2017 and 2017-2018.The experimental site was located in the foothill of Nagaland at the altitude of 305 meters above mean sea level (MSL) with geographical location of 25^o45’43” N latitude and 93^o53’04” E. The experimental plot was situated at the subtropical and sub-humid climatic condition in foothills of Nagaland.

A nutrient mixture of 100 kg FYM, 1000 g N_2, 700 g P_2O_5 and 1000 g K_2O per plant per year were applied in two split doses. Full amount of FYM and P_2O_5 and half of N_2 and K_2O were given just after harvesting of fruit (End of June). Rest N_2 and K_2O were applied 15 days after fruit set (1^{st} week of April) followed by irrigation with ring and basin method. The trees were selected randomly and death twig and unnecessary shoot were pruned before carrying out the experiment. Just after pruning operation, copper oxychloride paint was applied to the cut portions to avoid infestation by pathogen.

All the polyamine and growth regulators were sprayed twice, first spray at 15 days after fruit set (pea stage) and second spray was given at

30 days after fruit set (marble stage) using foot sprayer. The polyamine and growth regulators were dissolved in harvested rain water for facilitating proper dilution of particles into water. Before foliar application, the P^H of water was also checked and neutralized using NaOH solution. A sticker agent Indtron AE (non-ionic surfactant) was dissolved in the solution of chemicals for increasing residence time of the droplets onto the leaves.

The experiment was laid out in a Randomized Block Design (RBD) with six treatments and four replications. The various treatments were as follows: T_1:GA_3 @ 40ppm, T_2: NAA @ 40ppm,T_3: Putrescine @ 1.0 mM/L, T_4: GA_3 @ 40ppm + Putrescine @ 1.0 mM/L, T_5: NAA @ 40ppm + Putrescine @ 1.0 mM/L,T_6: Control. The fruits were harvested at fully matured and ripen stage since they do not ripen after harvest. Harvesting was done manually by picking the fruits. Observations on various growth and yield characters (fruit drop, relative water content of leaves, fruit cracking and aril recovery percent) were recorded as per the standard procedures. Total soluble solids (TSS) of the fruit were determined by EMRA hand refractometer (0-32°B) at 22.5^0 C with necessary correction factor.

Titratable acidity of the fruit juice was determined by titrating against N/10 NaOH using phenolphthalein indicator and expressed in percentage. 2, 6-dichlorophenol indophenol dye titration method was used to estimate the ascorbic acid content of fruit and expressed as mg 100 g^{-1} of pulp.

Anthocyanin content of the peel was determined by standard procedure as described by Raganna (2001) using spectrophotometer and petroleum ether as blank by optical density at 503 nm. Total sugar, reducing sugar and ascorbic acid were estimated using Fehling's A and B reagents with methylene blue as an indicator through copper reduction method (Anon., 2000a). Crude protein content of peel and pulp of litchi fruit was determined using the Kjeldahl method (Anon., 2000b) which involved protein digestion and distillation and was calculated by using formula: Crude Protein % = % Nitrogen X 6.25. The data were statistically analyzed employing randomized block design in accordance with the procedure outlined by Gomez and Gomez (2012).

Results and Discussion

Fruit drop and retention percentage

The fruit drop percentage was observed very high at 15 days after fruit set (DAFS) rangingbetween 37.17 % and 43.60 % during 2016-17 and between 35.08 % and 41.45 % during 2017-18 which then declined gradually with the advancement of fruit growth and continued till harvest and it was very less at 60 DAFS ranging from 0.65 % to 1.11 % in value during 2016-17 and between 0.57 % to 0.99 % during 2017-18. However, minimum fruit drop percentage (54.32% and 51.07%) was obtained from NAA @ 40 ppm in both the years in table1.

The present result is also in agreement with the findings of Iqbal *et al.,* (2009) who reported that trees sprayed with 45 ppm NAA reduced pre harvest fruit drop. Fruit drop is an abscission phenomenon controlled by the inter play of hormones Effectiveness of gibberellins in controlling fruit drop appears to be indirect and mediated through the formation of auxin (Krishnamoorthy, 1993).

Fruit retention percentage was noticed to vary significantly in different treatments in both the years, It varied from 32.60 % to 45.68 % during 2016-17 and 37.19 % to 48.93 %

during 2017-18 due to application of PGRs and Putrescine. The plants sprayed with NAA @ 40 ppm (T_2) caused augmentation of fruit retention in both the years with 45.68% in 2016-17 and 48.93% in 2017-18. Tewari *et al.,* (2017a) also confirmed that the maximum fruit retention was observed in NAA @ 50 ppm and GA_3 @ 50 ppm which were statistically at par with each other.

Relative water content in leaf and fruit cracking

Relative water content (RWC) in leaf by spraying growth regulators and polyamines varied significantly in both the years. The RWC of leaf ranged from 70.25 % to 77.77 % in 2016-17 and 71.81 % to 81.77 % during 2017-18.

However, the highest water content of leaf (77.77% in 2016-17 and 81.77% in 2017-18) was found in plants treated with GA_3 @ 40ppm + Putrescine @ 1.0 mM/L (T_4). The number of cracked fruits was found to vary from 2.30 % to 7.46 % in 2016-17 and 1 % to 4.03 % during 2017-18.

The maximum number of cracked fruit was found in control T_6 (5.75 %) and minimum fruit cracking (1.65 %) was noticed from T_4 (GA_3 @ 40 ppm + putrescine @ 1.0 mM/L). All the treatments showed significant increase in relative water content in leaf and as consequences it reduced in fruit cracking over control.

However, trees sprayed with GA_3 @ 40 ppm + putrescine @ 1.0 mM/L showed the highest leaf water content ultimately leading to less cracking of fruits. Polyamines (PAs) can regulate the size of pores in the plasma membrane of guard cells, thereby strongly regulating pore opening and closing. In this way, PAs can control water loss in plants (Liu *et al*., 2000).

Fruit weight and aril recovery percentage

The data presented showed significant variation among the treatments during both the years varying from 15.95 g to 20.20 g in 2016-17 and 16.10 g to 21.10 g in 2017-18 due to application of different plant growth regulations (PGRs) and polyamine (PA). However, plants sprayed with GA_3 @ 40 ppm caused maximum fruit weight with an average of 20.65 g.

The aril recovery of various treatments varied from 53.48 % to 64.36 % in 2016-2017 and 55.16 % to 65.40 % in 2017-18. Maximum average aril recovery percentage of 64.88 was obtained from treatment T_1 (GA_3 @ 40 ppm) followed by T_2 (NAA @ 40 ppm) with 62.96 %. Treatments with PGRs and PA in this experiment significantly increased the fruit weight and aril recovery of fruits. However, the effect of GA_3 @ 40 ppm and NAA @ 40 ppm was more pronounced compared with other treatments.

This increase in fruit weight may be due to better presence of GA_3 which regulates and photosynthates in plants and might have made a rapid synthesis of metabolites particularly carbohydrate and their translocation to the fruits causing a relatively greater content of pulp. The role of GA in improving fruit quantity may also be due to its role in increasing long elongation (Eman *et al*., 2007).

Khassawneh *et al.,* (2006) indicated that spraying with GA_3 seem to stimulate both cell division and cell enlargement which are by their turn are reflected on fruit weight increase. The present findings were also in complete agreement with the findings of Sharma *et al.,* (2019) who reported significant maximum weight of fruit with the application of 50 ppm concentration of GA_3 in aonla cv. NA-7.

Table.1 Effect of polyamine and growth regulators on yield and yield attributing characters of litchi cv. China

Treatment	Fruit drop (%)		Fruit retention (%)		Relative water content in leaf (%)		Fruit cracking (%)		Fruit weight (g)		Aril recovery (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
T_1: (GA_3 @ 40ppm)	57.14	52.85	42.86	47.15	74.64	74.95	2.87	1.64	20.20	21.10	64.36	65.40
T_2: (NAA @ 40ppm)	54.32	51.07	45.68	48.93	72.19	74.21	4.13	3.32	19.55	20.15	61.15	63.77
T_3: (Putrescine @1.0 mM/L)	62.46	56.91	37.54	43.09	75.75	78.44	3.28	1.20	17.05	18.70	57.07	59.36
T_4: (GA_3 @ 40 ppm + Putrescine @1.0 mM/L)	59.64	54.32	40.36	46.35	77.77	81.77	2.30	1.00	18.25	18.55	60.27	60.64
T_5: (NAA @ 40 ppm+Putrescine @1.0 mM/L)	61.53	55.73	38.47	44.27	76.42	80.19	4.21	2.25	17.90	17.95	58.66	59.89
T_6: (Control)	67.4	62.81	32.60	37.19	70.25	71.81	7.46	4.03	15.95	16.10	53.48	55.16
Sem±	2.18	2.00	0.86	0.90	1.30	1.49	0.14	0.11	0.36	0.56	1.19	1.13
CD at 5%	6.57	6.06	2.59	2.72	3.92	4.48	0.43	0,33	1.08	1.70	3.58	3.39

Table.2 Effect of polyamine and growth regulators on biochemical attributes of litchi cv. China

Treatments	TSS (ºB)		Total Sugar (%)		Reducing sugar (%)		Titratable acidity (%)		Ascorbic acid (mg/100g pulp)		Anthocyanin content in peel (mg/100g peel)		Crude protein content in pulp (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
T_1: (GA_3 @ 40ppm)	16.21	18.42	9.87	10.56	6.36	8.53	0.48	0.46	59.00	63.00	55.12	56.67	12.57	12.79
T_2: (NAA @ 40ppm)	16.55	17.08	10.29	10.03	7.27	8.26	0.50	0.48	57.00	63.00	59.76	59.86	12.69	13.13
T_3: (Putrescine @1.0 mM/L)	12.91	13.40	8.77	8.97	5.88	7.31	0.68	0.63	44.00	46.50	42.91	42.52	10.07	10.72
T_4: (GA_3 @ 40 ppm + Putrescine @1.0 mM/L)	15.90	15.51	9.45	9.80	7.62	7.41	0.54	0.51	59.50	60.00	50.52	51.66	11.38	12.25
T_5: (NAA @ 40 ppm+Putrescine @1.0 mM/L)	13.85	14.21	9.08	9.44	6.74	6.52	0.52	0.54	48.00	53.00	45.17	48.71	10.94	11.38
T_6: (Control)	13.00	13.33	8.19	7.69	6.03	6.22	0.67	0.69	43.80	43.50	40.92	40.74	9.83	10.40
Sem±	0.59	0.37	0.42	0.41	0.26	0.27	0.07	0.03	1.25	1.31	0.57	0.55	0.98	1.06
CD at 5%	1.78	1.11	1.27	1.22	0.79	0.81	0.21	0.08	3.76	3.96	1.73	1.67	NS	NS

Biochemical attributes

Regarding bio-chemical composition of fruits, it was found to vary significantly among the different treatments. Total soluble solids (TSS) varied from 13.00 ^{0}B to 16.55 ^{0}B during 2016-17 and 13.33 ^{0}B to 18.42 ^{0}B in 2017-18. The highest average TSS of 17.32 ^{0}B was obtained by spraying of GA_3 @ 40 ppm followed by average of 16.82 ^{0}B with NAA @ 40 ppm. The total sugar content varied significantly from 8.19 % to 10.29 % in 2016-17 and 7.69 % to 10.56 % during 2017-18. The total sugar content was found highest with average 10.22 % in T_1 (GA_3 @ 40 ppm) which was statistically at par with NAA @ 40 ppm with average 10.16 %.

Significant variation of reducing sugar was found among different type of treatment as showed in table 2 during both the years. The reducing sugar content of the fruits varied from 6.03 % to 7.62 % during 2016-17 and 6.22 % to 8.53 % during 2017-18. The plants sprayed with NAA @ 40 ppm showed the highest average reducing sugar of 7.76 %. The titratable acidity varied from 0.48 % to 0.68 % during 2016-17 and 0.46% to 0.63 % in 2017-18.

The lowest acidity (0.48% and 0.46%) was recorded by GA_3 @ 40 ppm in both the years. The ascorbic acid content in fruit was found to vary significantly ranging between 43.80 mg to 59.00 mg/100g pulp in 2016-17 and 43.50 mg to 63.00 mg/100g pulp during 2017-18 with the application of PGRs and putrescine. The highest average ascorbic acid content (61.00 mg/100 g of pulp) in the fruits was obtained by T_1 (GA_3 @ 40 ppm) which was at par with T_2 (NAA @ 40 ppm) with 60 mg/100 g of pulp. The plants sprayed with GA_3 @ 40 ppm showed the highest average anthocyanin content in the peel with 59.81 mg/100 g peel followed by T_2 (NAA @ 40 ppm) with 55.90 mg/100 g peel. Different sprays of PGRs and PA had no significant effect on the protein content in pulp during both the years. However, maximum protein content in pulp of 12.69 % and 13.13% was found in T_2 (NAA @ 40 ppm) during 2016-17 and 2017-18, respectively. The different treatments used in this investigation also influenced the quality of fruit.

Although all chemicals significantly improved the quality of fruits as compared to control, GA_3 @ 40 ppm showed maximum TSS, total sugar and ascorbic acid and minimum acidity followed by NAA @ 40 ppm. Gibberellins primarily affect growth by controlling cell elongation and division, which is reflected on yield and its components and fruit quality of various grape cultivars (Pires *et al*., 2000). Increase in content of TSS and total sugar may also be due to quick transformation of starch into soluble solids and rapid mobilization of photosynthetic metabolites and minerals from other parts of the plant to developing fruit (Singha, 2004).

The reason for decrease in acidity may be due to increased translocation of carbohydrates and increased metabolism due to conversion of acid to sugar during fruit ripening. These results are in agreement with Otmani *et al.*, (2004) who indicated that spraying GA_3 ppm significantly reduced acidity percentage. Tuan and Ruey (2013) also found that trees sprayed with GA_3 @ 30 ppm showed reduced acidity on wax apple.

The increase in ascorbic acid content may be attributed to the quality improving properties of GA_3 which is assigned the role of quality nutrient and may help in synthesis of ascorbic acid in developing fruits. Brahmachari and Rani (2001) conducted a field experiment in litchi and obtained maximum total sugar and lowest acidity in 50 ppm GA_3 which supports the present study. The present results are in complete agreement with the findings of

Tiwari *et al.,* (2017b) who observed that trees sprayed with 30 ppm GA_3 recorded maximum quality. Fruits from trees treated with NAA @ 40 ppm showed highest concentration of reducing sugar, anthocyanin content of the peel and protein content of the pulp, followed by GA_3 @ 40 ppm. Dutta *et al.,* (2011) reported that the anthocyanin content of litchi cv. Bombai was highest in fruits sprayed with 50 ppm NAA.

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