Annals of Plant and Soil Research 25(4): 609-613 (2023)
https://doi.org/10.47815/apsr.2023.10311

Effect of different plant bio regulators and chemicals on flowering and fruiting of litchi (*Litchi chinensis* Sonn.) grown in Nagaland

[*]K. AJAY KUMAR, C.S. MAITI, PAULINE ALILA, A. SARKAR AND [1]A.K. SINGH

Department of Horticulture, School of Agricultural Sciences, Nagaland University- 797106, Nagaland

Received: May, 2023; Revised accepted: September, 2023

ABSTRACT

A field experiment was carried out during 2020-22 to find out the effect of different plant bio regulators and chemicals on flowering and fruiting of litchi (Litchi chinensis Sonn.) at Experimental farm, Dept. of Horticulture, SAS, NU, Nagaland. The experiment was conducted with ten treatments with three replications in randomised block design. The trees were sprayed with different chemicals and PGRs alone and in combination to study the effect on flowering and fruiting of litchi cv. shahi. Among the various treatment combination, it was recorded that ethrel @ 400 ppm took lesser time for panicle initiation (29.01.22 and 27.01.22), flower induction (-9 days), time taken to fruit set (22.5 days), days to mature (50.5 days) and days to harvest (59.5). The plants treated with K_2HPO_4 @ 1% significantly influenced on number of flowers panicles^{-1} (881.0). The plants treated with GA_3 @ 100ppm showed high sex ratio (6.6%) and also improved fruit quality like total sugar (22.2%), TSS (20.3º B), TSS: acid ratio (46.9) and less acidity (0.4%).

Keywords: Litchi, bio-regulators, chemicals, flowering, fruiting, quality

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is a sub-tropical evergreen fruit tree and it needs highly specific climatic requirements for improving the fruit yield and quality. Litchi cultivation is restricted to few subtropical countries in the world, where it is grown commercially. India ranks second in the world next to China in litchi production. In India, 686.4 thousand metric tonnes of litchis are produced annually from 92.3 thousand hectares area and productivity 7.4 MT ha^{-1} and production period varies from the first week of May to the first week of July (NHB, 2018). National average productivity of litchi is 6.1 t/ha. The production of litchi is mainly confined to Bihar (40 %), West Bengal (16 %), Jharkhand (10 %), Assam (8.2 %), Chhattisgarh (6.4 %), Uttarakhand (5.2 %) and to a smaller extent in Punjab, Odisha and Tripura. Punjab recorded the highest productivity with 16.14 MT ha^{-1}. In Nagaland, North Eastern state of India with over 3.94 thousand MT production of litchi (NHB, 2018). Shahi, China and Tejpur litchi are the varieties grown in Nagaland. Shahi is predominant in the state of Nagaland. Nagaland has a good potentiality of producing litchi especially in the foothills of 4-12°C temperature for a month or more. The foothills and mid hills of Dimapur, Mokokchung, Wokha, Peren, Kohima and Zunheboto districts are also congenial for litchi cultivation. Fruit maturity in this state is quite late which comes in the market up to the last week of June. Litchi flowers are small, greenish and are borne on a large thyrse (a many-flowered inflorescence) that emerges at the ends of branches from late December to April (more commonly February and March). Flowers of different sexes are on the panicle, do not open simultaneously (Pandey and Sharma, 1984). The fruit is a nut and fruits are borne in loose clusters numbering from 3 to 50 fruits and edible portion of the fruit (pulp) is called an aril that is succulent, whitish, translucent, with excellent subacid flavour. Fruits contain one shiny, dark brown seed, usually relatively large, but it may be small and shrivelled (called chicken tongues) in some varieties. Fruit must be ripened on the tree for best flavour. It comes to the market in the months of May-June when the market is full of other fresh fruits. In spite of the availability of different types of fruits in the market, the demand for fresh litchi is always very high due to its unique taste, flavour and colour. The food value of litchi mainly lies in its sugar and acid contents which again vary due to cultivars and climate. There is an extreme need to make Indian litchi globally competitive since it is highly export oriented in nature and has great latent to earn foreign exchange in the international markets. The short span of availability of fruits coupled with poor shelf-life

Corresponding author email: kurbahorti1301@gmail.com, [1]Dept. of Soil Science, School of Agricultural Sciences, Nagaland University- 797106, Nagaland

limits the duration of availability of fruits in national and international markets. Pre-harvest application of various chemicals have been reported to reducing physiological loss in weight, decay losses during storage (Gupta *et al.* 1988; Kumar *et al.* 2017) and fruit cracking (Rathore *et al.* 2009; Mitra *et al*. 2010; Sarkar *et al*. 2020). Applying various plant growth regulators and chemicals can help litchi orchardist to manage their orchard in such a way that it will have better quality production. Foliar application of calcium on the fruit is essential to strengthen the cell wall, cell membrane integrity, and thereby, reducing the physiological disorders (Fallahi *et al.* 1997) and improving fruit quality (Malakouti *et al.* 1999). Higher fruit quality attributes were recorded with GA3 (40 ppm) followed by GA3 20 ppm over other treatments. Mandal *et al.* (2014) observed that the ethrel (2 mL/L) was most effective for flower induction and fruit quality in litchi cultivar 'Bombai'. Many investigations reported the use of potassium salts (K_2HPO_4 or KNO_3) as a chemical agent for induction of plant resistance and induction of flowering. Therefore, plant growth regulators have been used for many years to alter the fruit plant behaviour for the economic benefits such as to control the vegetative growth, advance in flowering and fruit set, stimulation of maturity and ripening and improving fruit quality.

MATERIALS AND METHODS

The investigation was conducted in instructional cum research farm, Department of Horticulture, School of Agriculture Sciences, Nagaland University, Medziphema campus, Nagaland. The experiment was laid out in Randomized Block Design. Plant bio-regulators and chemicals (Potassium nitrate, Dipotassium phosphate, Gibberellins and Ethrel) were sprayed before flowering once in a month from September to December, (in both the year 2020 and 2021) four times with different combinations of plant bio-regulators and potassium forms to induce early flowering and fruit induction. Different chemicals and PGRs alone and in combination ten treatments with three replications included T_1 (KNO_3 1%), T_2 (K_2HPO_4 1%), T_3 (Ethrel 400ppm), T_4 (GA_3 100ppm), T_5 (KNO_3 1% +K_2HPO_4 1%), T_6 (KNO_3 1% + Ethrel 400ppm), T_7 (KNO_3 1% + GA_3 100ppm), T_8 (K_2HPO_4 1% + Ethrel 400ppm), T_9 (K_2HPO_4 1% + GA_3 100ppm) and T_{10} (No-spray). The parameters like date of panicle initiation, advancement of flowering, sex ratio (F-M), days taken to fruit maturity and days taken for harvest were observed under the experiment. Total soluble solids (TSS) were determined with the help of hand refractometer calibrated in ^{0}Brix at 20 ^{0}C with necessary correction factor. Total sugar was determined using Fehling's reagents with methylene blue as an indicator and acidity by titrating the extracted juice against N/10 NaOH using phenolphthalein as an indicator following the standard procedure of A.O.A.C (1995). TSS: acid ratio was calculated by dividing the TSS by titratable acidity in each treatment**.**

RESULTS AND DISCUSSION

The data pertaining to the effect of different bio regulators and chemicals on improvement of flowering and fruiting intensity of litchi were statistically analysed and the results are presented in this chapter. Panicle initiation was observed at the earliest in treatment T_3 (ethrel @ 400 ppm) *i.e*., on 29th January and 27th January, respectively during the year 2021 and 2022 as compared to T_4 (GA_3 @ 100 ppm) *i.e*., on 27th February and 25th February during both the years, respectively (table 1). Similar results had been reported by Dongariyal (2017) who observed early panicle initiation in litchi on 16th February in treatment T_1 (ethrel @ 400 ppm). This might be due to early maturation of shoots that induces early panicle initiation and lateral expansion and promotes compact flower panicles. The earliest flowering (9 days) was recorded in Treatment T_3 (ethrel @ 400 ppm) followed by T_2 (K_2HPO_4 @1%) and T_1 (KNO_3 @ 1%) *i.e*., 8 and 6 days early than the control (no-spray). In the treatment T_4 (GA_3 @ 100 ppm) 2 days delayed flowering occurred than control. Dalal *et al*. (2005) also reported that application of KNO_3 @ 1.5 % advanced the flowering by 4-5 days in mango cv. Pairy. On the other hand, all the treatments had a significant effect on total number of flowers as compared to control. Maximum number of flowers (881.0) were observed in T_2 (KH_2PO_4 @ 1 %) treatment whereas minimum flowers (255.5) were reported in control (no-spray). Increase in number of flowers panicle^{-1} by different forms of potassium might be due to increased concentrations of

zeatin or zeatin riboside which helps in flower induction promoters present in it (Guevara *et al.,* 2012). The pooled data of sex ratio (F-M) revealed that among all the treatments minimum (0.7) was observed in control (no-spray) whereas, T_4 (GA_3 @ 100ppm) recorded the maximum sex ratio (6.6). The chemical treatment increased the percentage of hermaphrodite flowers over control, resulting in higher sex ratio, which might be due to the availability of more nutrients to the panicles (Sarkar, 2009).

Table 1: Effect of PGR and chemicals on floral induction and sex ratio of litchi

Treatments	Date of Panicle initiation		Advancement of flowering (Days)			Number of flowers panicle^{-1}			Sex ratio (F-M) (%)		
	2021	2022	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1: (KNO_3 1%)	04.02.21	02.02.22	-5	-7	-6	420.2	582.6	501.4	2.8	3.3	3.0
T_2: (K_2HPO_4 1%)	30.01.21	30.01.22	-8	-8	-8	875.9	886.1	881.0	4.6	5.3	5.0
T_3: (Ethrel 400ppm)	29.01.21	27.01.22	-8	-10	-9	850.6	811.3	831.0	2.1	1.9	2.0
T_4: (GA3 100 ppm)	27.02.21	25.02.22	+3	+1	+2	520.8	447.0	483.9	6.7	6.5	6.6
T_5 :(KNO31%+$K_2HPO_4$1%)	06.02.21	05.02.22	-4	-5	-4.5	830.2	854.0	842.1	3.2	3.3	3.2
T_6:(KNO_3 1% + ethrel 400ppm)	15.02.21	12.02.22	-2	-3	-2.5	590.8	662.0	626.4	1.5	1.9	1.7
T_7:($KNO_3$1% +GA3 100 ppm)	16.02.21	17.02.22	-2	-1	-1.5	643.2	606.3	624.8	3.8	4.3	4.0
T_8: (K_2HPO_4 1% + ethrel 400ppm)	09.02.21	12.02.22	-7	-6	-6.5	500.1	405.2	452.6	3.5	2.9	3.2
T_9: (K_2HPO_4 1%+GA3 100 ppm)	23.02.21	20.02.22	-2	-4	-3	822.0	710.6	766.3	4.8	4.3	4.5
T_{10}: (No- spray)	20.02.21	22.02.22	0	0	0	245.8	265.3	255.5	1.3	0.2	0.7
SEm±	-	-	-	-	-	1.3	52.8	41.4	0.1	0.3	0.2
CD (P=0.05)	-	-	-	-	-	4.3	158.2	134.3	0.5	0.9	0.9

Kumar *et al*. (2017) reported that number of female flowers panicle^{-1} was maximum (86.3) in trees sprayed with KH_2PO_4 @ 1%. Spray of ethrel @ 400 ppm has the least sex ratio due to very large number of male flower panicle^{-1} (118.6) while control trees had the lowest number of female flowers panicles^{-1} (36.5). Ethrel @ 400 ppm took minimum time (22.5 days) among all the treatments to set fruit, whereas treatment T_4 (GA_3 @ 100ppm) took maximum time (34.5 days) for fruit set. The minimum days for maturity (50.5 days) was observed in T_3 (ethrel @ 400 ppm) whereas the T_4 (GA_3 @ 100ppm) reported maximum days for maturity (61.0 days). Minimum days to harvest after fruit set (59.5 days) was observed in T_3 (ethrel @ 400 ppm) treatment, whereas the treatment T_4 (GA_3 @ 100ppm) recorded the maximum days for harvesting (70.0 days). The duration from fruit set to harvesting varied from 59.5 to 70.0 days in all the treatments.

Table 2: Effect of PGR and chemicals on fruit set, fruit maturity and harvesting of litchi

Treatments	Time taken to fruit set (Days)			Days to mature after fruit set			Days taken to harvest after fruit set		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1: (KNO_3 1%)	28.0	25.0	26.5	55.0	53.0	54.0	66.0	65.0	65.5
T_2: (K_2HPO_4 1%)	23.0	24.0	23.5	52.0	52.0	52.0	61.0	62.0	61.5
T_3: (Ethrel 400ppm)	23.0	22.0	22.5	51.0	50.0	50.5	59.0	60.0	59.5
T_4: (GA3 100 ppm)	36.0	33.0	34.5	62.0	60.0	61.0	72.0	68.0	70.0
T_5: (KNO_3 1% + K_2HPO_4 1%)	28.0	27.0	27.5	54.00	55.0	54.5	62.0	63.0	62.5
T_6:(KNO_3 1% + ethrel 400ppm)	31.0	29.0	30.0	56.0	54.0	55.0	68.0	66.0	67.0
T_7: (KNO_3 1% + GA3 100 ppm)	30.0	31.0	30.50	58.0	54.0	56.0	70.0	67.0	68.5
T_8:($K_2HPO_4$1%+ethrel 400ppm)	26.0	26.0	26.	52.0	53.0	52.5	63.0	65.0	64.0
T_9:(K_2HPO_4 1%+GA3 100 ppm)	30.0	28.0	29.0	57.0	55.0	56.0	66.0	64.0	65.0
T_{10}: (No- spray)	30.0	29.0	29.5	59.0	56.0	57.5	69.0	70.0	69.5

The data presented in table 3 depicted that all the treatments significantly affected bio-chemical attributes of fruits. The pooled analysis of total sugar content indicated that maximum total sugar content (22.2 %) was found in treatment T_4 (GA_3 @ 100ppm) followed by T_3 (ethrel @ 400 ppm) (20.4 %). On the other hand, minimum total sugar content (10.0 % and 10.5 %) was found in treatment T_1 (KNO_3 @ 1%) and T_{10} (no spray). The maximum TSS content (20.3 ºB) was observed in treatment T_4 (GA_3 @ 100ppm) followed by T_3 (ethrel @ 400 ppm) (18.0 ºB) while the minimum TSS content (14.8 ºB) was recorded in T_1 (KNO_3 @ 1%). This might be due to the conversion of sugars and other polysaccharides into soluble sugars lead to the increase in the reducing and total sugar by ethephon spray. A critical examination of pooled data indicated that treatment T_{10} (no spray) resulted in maximum acidity (0.7 %) in fruit, which was at par (0.7 %) with T_2 (K_2HPO_4 @ 1%) while, the minimum acidity of 0.4 % and 0.5 % was recorded in T_4 (GA_3 @ 100ppm) and T_3 (ethrel @ 400 ppm), respectively. Declining of acidity by application of ethrel has been supported by Abbas *et al*. (1994) in jujube fruits. The treatments T_4 (GA_3 @ 100ppm) and T_3 (ethrel @ 400 ppm) showed the highest TSS: acid ratio of 46.9 and 33.5, respectively while, T_2 (K_2HPO_4 @ 1%) as well as T_{10} (no spray) resulted in the lowest TSS: acid ratio of 21.7 and 22.6 respectively. Increase in TSS: acid ratio by application of ethrel is due to increase in TSS and decrease in acidity. This may be due to early and rapid degradation of acid and its conversion into sugars (Korunga *et al.,* 2007; Sarkar *et al.,* 2020).

Table 3: Effect of PGR and chemicals on bio chemical traits of litchi fruits

Treatments	Total sugar (%)			TSS (ºB)			Titratable acidity (%)			TSS: Acid ratio		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_1: (KNO_3 1%)	10.0	10.1	10.0	14.5	15.1	14.8	0.6	0.6	0.6	24.2	22.3	23.2
T_2: (K_2HPO_4 1%)	11.6	11.9	11.8	15.3	15.3	15.3	0.6	0.7	0.6	22.6	20.9	21.7
T_3: (Ethrel 400ppm)	20.0	20.8	20.4	17.5	18.6	18.0	0.5	0.5	0.5	31.9	35.1	33.5
T_4: (GA3 100 ppm)	21.8	22.6	22.2	20.1	20.4	20.3	0.4	0.4	0.4	50.4	43.5	46.9
T_5: (KNO_3 1% + K_2HPO_4 1%))	11.3	10.8	11.0	16.5	16.1	16.3	0.5	0.5	0.5	29.5	29.7	29.6
T_6: (KNO_3 1% + ethrel 400ppm)	11.6	9.3	10.5	15.3	15.4	15.3	0.6	0.7	0.7	23.5	22.0	22.8
T_7: (KNO_3 1% + GA3 100 ppm)	10.9	10.6	10.7	16.6	16.5	16.5	0.5	0.6	0.5	29.2	29.0	29.1
T_8: (K_2HPO_4 1% + ethrel 400ppm)	12.0	11.5	11.8	15.4	15.3	15.4	0.5	0.5	0.5	28.1	27.3	27.7
T_9: (K_2HPO_4 1% + GA3 100 ppm)	18.4	19.2	18.8	16.5	16.8	16.6	0.6	0.5	0.5	27.6	27.8	27.7
T_{10}: (No- spray)	10.2	10.8	10.5	16.1	16.5	16.3	0.6	0.7	0.7	23.7	21.6	22.6
SEm±	0.3	0.7	0.4	0.1	1.0	0.2	0.2	0.3	0.2	0.6	2.8	1.2
CD (P=0.05)	1.1	2.2	1.5	0.5	3.0	0.6	0.7	0.9	0.7	2.2	9.1	4.1

In the case of above study, findings revealed that different chemicals and PGRs significantly affected on early flowering, fruiting, quality attributes of litchi cv. shahi grown in Nagaland. Spraying of GA_3 @ 100 ppm and ethrel @ 400 ppm was observed to perform better in respect to flowering, fruiting advancement and quality improvement.

REFERENCES

Abbas, M.K., Niami, J.H. and Sereh, E.A. (1994) The effect of ethephon on ripening of fruits of jujube. *Journal of Horticultural Science* **401**: 465-466.

A.O.A.C. (1995) Official Method of Analysis. Association of official analytical chemist, Washington D.C, USA, 14th Edn.

Dalal, S. R., Gonge, V.S., Jadhao, B. J. and Jogdande, N.D. (2005) Effect of chemical on flowering and fruit yield of mango cv. Pairy. *International Journal of Agricultural Science* **1**(1): 24-25.

Dongariyal, A. (2017) Effect of ethrel and other chemicals for improving flowering and bearing potential of litchi (*Litchi chinensis* Sonn.). *M.Sc Thesis*, Agriculture (Horticulture) GBPUA&T, Pantnagar.

Fallahi, E., Conway, W.S., Hickey, K.D. and Sams, C.E. (1997) The role of calcium and nitrogen in postharvest quality and disease resistance of apples. *Horticulture Science* **32**: 831–835.

Guevara, E., Victor, M., Jimenez, F. and Bangerth, K. (2012) Response of endogenous hormone concentrations to two floral inductive treatments, *viz*. KNO_3 and PBZ in Mango cv. Tommy Atkins growing under tropical conditions. *Tropical Plant Biology* **2**: 253-260.

Gupta, O.P. and Metha, N. (1988) Effect of Calcium and Boron on the Quality of Kiwifruit. *Journal of Horticultural Science* **17**:183-189.

Korunga, K., Mankar, A. and Singh, J. (2007) Effect of growth substances on yield and quality of mango cv. Langra. *The Orissa Journal of Horticulture* **35** (1): 67-70.

Kumar, J., Kumar, R., Rai, R., Mishra, D.S., Singh, S. K. and Nimbolkar, P. K. (2017) Effect of Plant Bio-Regulators and Nutrients on Fruit Cracking and Quality in Pomegranate (*Punica granatum* L.) 'G-137' in Himachal Pradesh. *Journal of Plant Nutrition* **40**:656-661.

Malakouti, M.J., Tabatabaei, S.J., Shababi, A.A. and Fallahi, E. (1999) Effects of CaCl2 on apple fruit quality of trees grown in calcareous soils. *Journal of Plant Nutrition* **22**: 1451-1456.

Mandal, D., Sarkar, A. and Ghosh, B. (2014) Induction of flowering by use of chemicals and cincturing in 'Bombai' Litchi. *Acta Horticulturae* **30** (1):265- 271.

Mitra, S.K. Pathak, P.K., Debnath, S., Sarkar, A. and Mandal, D. (2010) Elucidation of the factors responsible for cracking and sunburn in litchi and integrated management to minimize the disorders. *Acta Horticulturae* **863**: 225-233

NHB. (2018) Final Area & Production Estimates for Horticulture Crops for 2017-2018, Area and production statistics, National Horticulture Board, Ministry of Agriculture, GOI.

Pandey, R.M. and Sharma, H.C. (1984) The Litchi, ICAR New Delhi.

Rathore, N., Mishra, N.K., Lal, R.L. and Mishra, D.S. (2009) Effect of mineral nutrient sprays on yield and quality of litchi fruits (*Litchi chinensis* Sonn.) cv. Rose Scented. *Indian Journal of Horticulture* **66**:524-525.

Sarkar, A. (2009) Orchard management practices for quality litchi (*Litchi chinensis* Sonn.) production. *PhD thesis* submitted in Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, WB.

Sarkar A, Bam, G. and Sumi, M. (2020) Impact of chemicals in management of fruit cracking and improving the quality in litchi cv. china in foot hill of Nagaland. *Journal of soils and Crops* **30** (1): 26-30.