International Journal of Plant & Soil Science

33(18): 176-181, 2021; Article no.IJPSS.72976
ISSN: 2320-7035

Effect of Plant Growth Regulators and Micro-nutrients on Vegetative Growth, Flowering and Yield Attributes of Litchi (*Litchi chinensis* Sonn.)

Oyinti Megu[1], B.N. Hazarika[1], L. Wangchu[1], P. Sarma[1], Amit Kumar Singh[1], P. Debnath[1] and Thejangulie Angami[2*]

[1]College of Horticulture and Forestry, CAU, Pasighat-791102, Arunachal Pradesh, India.
[2]ICAR (Research Complex) for NEH Region, AP Centre, Basar-791101, Arunachal Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i1830587
Editor(s):
(1) Dr. Muhammad Shehzad, The University of Poonch Rawalakot, Pakistan.
Reviewers:
(1) Noor-ul-Huda Altaf, University of Agriculture Faisalabad, Pakistan.
(2) Isaias Vitorino Batista de Almeida, Brazil.
Complete Peer review History: https://www.sdiarticle4.com/review-history/72976

Original Research Article

Received 20 June 2021
Accepted 26 August 2021
Published 30 August 2021

ABSTRACT

The experiment was conducted to observe the effect of plant growth regulators (GA_3 and NAA) and micro-nutrients ($ZnSO_4$ and Borax) on vegetative growth, flowering and yield attributes of litchi (*Litchi chinensis* Sonn.). $ZnSO_4$ applied @ 0.4% resulted in maximum per cent increase in plant height and canopy spread, i.e. 5.78% and 6.65% respectively. Whereas, application of Borax @ 0.4% exhibited maximum per cent increase in plant girth (8.72%). NAA @ 2.5 ppm was effective in improving the flowering parameters of litchi. With respect to physical parameters of fruit and yield component, application of borax @ 0.4% resulted in maximum fruit set (43.76%), number of fruits per tree (1128.67), fruit yield (25.11 kg/tree), fruit weight (22.24 g), aril weight (15.65 g) and minimum fruit cracking (5.08%). Lowest fruit drop percentage (60.91%) was however caused by application of $ZnSO_4$ @ 0.4%.

Keywords: PGR; micronutrients; vegetative; flowering; yield; litchi.

**Corresponding author: E-mail: thejaangami@yahoo.com;*

1. INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is considered as one of the most important sub-tropical fruit crops. It belongs to the family Sapindaceae and sub-family Nepheleae comprising about 150 genera and 2000 species [1]. India retains the title of second largest producer of litchi in the world after China with an area and production of 92,000 hectares and 6, 86,000 MT respectively during 2017-2018 [2]. Cumulative production of Bihar, West Bengal, Jharkhand and Assam accounts for 64.2% of the total litchi production in the country. In Arunachal Pradesh, the commercial cultivation of litchi is in nascent stage with an area and production of 40 hectares and 80 MT respectively during 2017-2018 [2]. Various problems offer challenges and cause low economic potential in litchi cultivation which include poor fruit set [3], heavy fruit drop [4], fruit cracking [5] and inferior fruit quality [6]. Low rate of pseudo-hermaphrodite flowers and high nutrient competition between organs often result in low yields in litchi [7]. Fruit drop in litchi is often thought to be associated with disturbance in the endogenous hormonal level [8], failure of fertilization, embryo abortion, internal nutrition and hormonal imbalance and internal factors like high temperature, low humidity and strong winds [9]. Postulation made by Fivaz and Robbertse [10] indicates that the high incidence of fruit abscission in litchi could be caused by a physiological rather than a genetic problem.

Over the years plant growth regulators (PGRs) and micronutrient have been consistently used to augment maximum and sustained economic benefits in litchi production through altering the behaviour of fruit or fruit plants. Yield and quality of litchi fruit have been positively influenced by both micronutrients and plant growth regulators [4]. Application of PGRs results in increased flowering, fruiting and retention of fruit. The supply route of cell sap to fruit is severed by formation of abscission layer and gradually thin cork cells separate resulting in fruit dropping [11]. Early researchers like Adams et al. [12] reported that gibberellins influenced both cell division and cell enlargement. Auxins like Naphthalene acetic acid (NAA) greatly influence plant growth, however, its effectiveness is dependent on the time of application and concentration. Application of NAA in different concentrations successfully control fruit drop in majority of fruit plants although required in very small quantities. Micronutrients have a significant function in improving the growth, yield and quality of litchi. Micronutrients applied in optimum concentrations results in better plant growth which leads to higher yield, better flowering and higher fruit set [13]. Plants require a substantial amount of the total requirement of certain micronutrients to be fed through foliar application which results in improved fruit quality [11]. Metabolic activities of plants greatly depend on zinc. Zinc primarily functions as a metal activator of enzymes like dehydrogenase (Pyridine nucleotide, glucose - 6 phosphodiesterase, carbonic anhydrase etc.). Tryptophan, a precursor of IAA greatly depends on Zinc for its synthesis, it is associated with water uptake and water retention in plant bodies [11]. Boron is invariably essential for important reproduction functions like germination of pollen tube and fertilization. Boron deficiency leads to lesser flower numbers with more of sterile ones, fruits produced are mostly deformed and are rendered commercially unviable [14]. Stunted growth, reduced flower induction and fruit set, eventually leading to inferior fruit quality are caused by zinc and boron deficiency [15]. Based on this context, an experiment was executed to assess the influence of PGRs and micronutirents on vegetative growth, flowering and yield of Litchi var. Muzzaffarpur under the foothill condition of Arunachal Pradesh.

2. MATERIALS AND METHODS

The experiment was carried in 8-9 years old litchi orchard during 2018 and 2019 at Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The geographical location of the research farm is 28° 04′ 43″ N latitude and 95° 19′ 26″ E longitude and having an altitude of 153 m above mean sea level. The climate of this area is generally humid sub-tropical and maximum rainfall occurs between April to September. The experiment was laid out in Randomized Block Design consisting of twelve treatments (Table 1) with three replications with three plants in each replication. The plants were planted at spacing of 8m x 8m. The experimental materials for the study comprised of plant growth regulators - GA_3 and NAA and micronutrients - $ZnSO_4$ as Zn source and borax as B source. They were applied as foliar spray at different concentrations three times at intervals (before flowering, fruit set and at green mature stage). Five litres of prepared solution were sprayed to each tree at each interval. The data were recorded for morphological parameters of tree (per cent increase in plant height, per cent increase in plant girth and per cent increase in canopy spread), flowering parameters of tree (time of flowering i.e., number of days taken for flowering after imposition of treatment and duration of flowering) and physical parameters of fruit and yield components *viz.* fruit set (%), fruit drop (%), maturity, fruit cracking (%), number of fruits per tree, fruit yield (kg/tree), aril weight (g) etc. Observations recorded during field experiment and data obtained from laboratory analysis 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 [16].

Table 1. Detailed information of treatments

Treatments	Details
T_1	GA_3 foliar spray @ 5 ppm
T_2	GA_3 foliar spray @ 10 ppm
T_3	GA_3 foliar spray @ 15 ppm
T_4	NAA foliar spray @ 2.5 ppm
T_5	NAA foliar spray @ 5.0 ppm
T_6	NAA foliar spray @ 7.5 ppm
T_7	Borax foliar spray @ 0.2%
T_8	Borax foliar spray @ 0.4%
T_9	Borax foliar spray @ 0.6 %
T_{10}	$ZnSO_4$ foliar spray @ 0.2 %
T_{11}	$ZnSO_4$ foliar spray @ 0.4 %
T_{12}	$ZnSO_4$ foliar spray @ 0.6 %

3. RESULTS AND DISCUSSION

3.1 Effect of PGRs and Micronutrients on Vegetative Growth Parameters

The vegetative growth parameters affected by PGRs and micronutrients is shown in Table 2. The maximum increase in plant height (5.78%) as well as maximum increase in canopy spread (6.65%) was recorded in T_{11} (zinc sulphate @ 0.4%). The maximum increase in plant height and canopy spread with the application of zinc sulphate could be attributed to higher auxin concentration resulting in increased apical growth. Tryptophan being the precursor of auxin and for tryptophan synthesis zinc is required as pointed by Kumar et al. [17]. As per Bowler et al. [18] a large number of enzymes depend on zinc for functional, structural or regulatory role. Further, Singh et al. [19] reported that zinc is believed to facilitate cell division, meristematic growth in apical tissues, cell enlargement and actively involved in new cell wall synthesis. Maximum increase in plant girth (8.72%) was recorded in T_8 (borax @ 0.4%) as boron is responsible for maintaining the structure of cell wall membranes, its integrity and function in plants suggested by Brown et al. [20].The increase recorded in the present study in connection with vegetative growth parameters following application of borax and zinc sulphate are in agreement with the works of Khan et al. [21] on citrus, Meena et al. [22] on aonla and Dhurve et al. [23] on pomegranate.

3.2 Effect of PGRs and Micronutrients on Flowering Parameter

The minimum time taken for flowering (10.50 days) and minimum duration of flowering (21.33 days) was recorded in T_4 (NAA@ 2.5 ppm) shown in Table 2. Young and Harkness [24] reported that initiation of floral buds takes place after a mandatory period of vegetative dormancy. Vegetative dormancy is successfully induced by administration of exogenous auxins to promote floral initiation in litchi as concluded by Menzel [1]. Levels of auxin produced during periodical shoot flush are likely to form a periodic reserve of concentrated auxin, which moves basipetally to the roots as suggested by Davenport [25]. Thus the elevated auxin concentration arriving at the roots may affect initiation of new root flushes. Sultana et al. [26] reported an increased inflorescence count with 75% inflorescence retention in litchi plant.

3.3 Effect of PGRs and Micronutrients on Physical and Yield Attributes

The physical and yield attributes affected by PGRs and micronutrients is shown in Table 3. T_8 (borax @ 0.4%) was most effective in increasing fruit set (43.76%) closely followed by T_{11} (zinc sulphate @ 0.4%) with fruit set of 43.38%. The increase in fruit set following application of borax might be due improved translocation of carbohydrates, auxins synthesis and increased pollen viability and fertilization, because boron plays a vital role in all these processes as described by Kaur [27]. Similar finding was also reported by Dixit et al. [28] in litchi.

Significant reduction in fruit drop (60.91%) followed by (61.54%) was recorded in T_{11} ($ZnSO_4$ @0.4%) and T_{12} ($ZnSO_4$ @ 0.6%) respectively. Response to zinc sulphate application was more positive, presumably due to zinc, which is known to be essential for the biosynthesis of auxin (IAA), an activator of the enzyme tryptophan synthesis. Increased fruit retention following the treatments suggests that zinc influenced and assisted in maintenance of optimum auxin balance and thus prevented fruit drop. Similar finding was expressed by Singh et al. [29].

Fruit cracking to the tune of 5.08% followed by 5.26% was found to be significantly lowest with T_8 (borax @ 0.4%) and T_3 (GA_3@ 15 ppm) treatments respectively. This is due to the fact that boron is responsible for pectin synthesis, increasing the elasticity of the cell membranes and prevents the breakdown of vegetative tissues as reported by Marboh et al. [30].

Fruit count per tree (1128.67) and fruit yield (25.11 kg/tree) was observed to increase considerably in treatment T_8 (borax @ 0.4%). This may be due to the fact that boron effects pollinations and development of viable seeds which in turn affect the normal development of fruit as reported by Suman et al. [31]. Apart aiding in cell division, cell elongation, cell enlargement, boron causes reduction of abscission layer which encourages fruit retention and finally results into higher number of fruits per tree as per Salisbury and Ross [32].

Table 2. Effect of PGRs and micro-nutrients on vegetative growth and flowering parameters of litchi (2018-2019 pooled data)

Treatments	Per cent increase in plant height	Per cent increase in plant girth	Per cent increase in canopy spread	Time of flowering	Duration of flowering
T_1	2.16	5.17	3.65	14.67	25.50
T_2	2.91	4.59	4.46	13.50	24.83
T_3	4.23	6.94	5.38	15.50	26.33
T_4	2.18	5.25	3.12	10.50	21.33
T_5	2.43	5.51	3.58	11.33	22.67
T_6	2.80	6.68	4.64	11.67	23.17
T_7	4.35	7.20	4.99	12.67	25.00
T_8	5.39	8.72	5.95	11.00	22.67
T_9	5.21	8.24	5.19	14.00	24.83
T_{10}	5.12	6.13	5.15	12.00	23.67
T_{11}	5.78	6.37	6.65	10.83	21.67
T_{12}	5.37	8.11	5.57	14.33	26.00
Mean (s)	**3.99**	**6.57**	**4.86**	**12.67**	**23.97**
S.E. (m) ±	**0.04**	**0.10**	**0.07**	**0.32**	**0.34**
C.D. (5%)	**0.11**	**0.29**	**0.19**	**0.95**	**1.01**

Table 3. Effect of PGRs and micro-nutrients on physical and yield parameters of litchi (2018-2019 pooled data)

Treatments	Fruit set (%)	Fruit drop (%)	Fruit cracking (%)	Number of fruits per tree	Fruit yield (kg/tree)	Fruit weight (g)	Aril weight (g)
T_1	39.86	77.43	6.99	997.00	18.71	18.77	11.41
T_2	40.95	69.58	6.33	897.50	17.38	19.33	12.48
T_3	41.72	64.99	5.26	983.50	21.38	21.67	13.91
T_4	40.26	76.22	6.54	927.00	17.22	18.53	11.57
T_5	41.44	67.50	7.48	943.50	18.52	19.60	12.64
T_6	42.21	64.16	7.83	834.67	17.41	20.88	14.19
T_7	39.95	79.59	5.99	952.17	19.75	20.74	14.26
T_8	43.76	62.50	5.08	1128.67	25.11	22.24	15.65
T_9	43.16	64.57	5.55	1069.67	22.94	21.44	14.88
T_{10}	40.21	74.08	6.10	858.50	17.36	20.22	13.61
T_{11}	43.38	60.91	5.39	1096.00	24.05	21.94	15.56
T_{12}	42.16	61.54	5.64	1005.33	21.42	21.29	14.54
Mean (s)	**41.59**	**68.59**	**6.18**	**974.46**	**20.10**	**20.55**	**13.72**
S.E. (m) ±	**0.50**	**0.52**	**0.26**	**32.38**	**0.83**	**0.38**	**0.36**
C.D. (5%)	**1.47**	**1.54**	**0.75**	**94.96**	**2.44**	**1.10**	**1.05**

Maximum fruit weight (22.24 g) was noted in T_8 (borax @ 0.4%) followed by T_{11} (ZnSO4 @ 0.4%) with fruit weight (21.94 g). As reported by Haq et al. [33], application of boron and zinc boosted the auxin levels in many parts of fruit affecting the cell size to undergo a rapid expansion which eventually facilitated a significant fruit growth resulting into higher fruit weight.

The maximum aril weight (15.65 g) was significantly increased with the application of borax @ 0.4% (T_8). The application of boron enhanced the aril weight thereby enhancing the juice content of the fruit. Findings from the present study are in conformity with that of Kaur [27] and Singh et al. [34].

4. CONCLUSION

All the observed parameters were significantly influenced by the application of plant growth regulators and micro-nutrients. Application of $ZnSO_4$ @ 0.4% gave maximum per cent increase in plant height and canopy spread, while borax @ 0.4% gave maximum per cent increase in plant girth. So, $ZnSO_4$ and borax both @ 0.4% are most appropriate for regulating vegetative growth of litchi. Application of 0.4% borax resulted into maximum fruit set, fruit weight, number of fruits per tree, fruit yield, aril weight and $ZnSO_4$ @ 0.4% exhibited minimum fruit drop. NAA @ 2.5 ppm was effective in improving the flowering parameters of litchi. Borax and $ZnSO_4$ @ 0.4% each were recorded to be more effective on most of the characteristics. Therefore, it can be inferred that the foliar spray of borax and $ZnSO_4$ @ 0.4% proved to be beneficial and best for better vegetative growth, flowering and yield of litchi.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Menzel CM. In: Plant resources of South-East Asia. No.2. Edible Fruit and Nuts (Eds. Verheij EWM and Coronel RE), Pudoe, Wageningen. 1991;191.
2. Anonymous. Area and production of horticultural crops- All India, Department of Agriculture Cooperation and Farmers Welfare, Ministry of Agriculture; 2018. Available:www.agricoop.nic.in
3. Sarkar GK, Sinha MM, Misra RS. Effect of NAA on fruit set, fruit drop, cracking, fruit size and quality in litchi cv. Rose Scented. Progressive Horticulture. 1984;16(3-4):301-304.
4. Singh OP, Phogat KPS. Effect of plant growth regulators on fruit drop, size and quality of litchi cv. Calcuttia. Punjab Horticulture Journal.1984;24(1-4):83-88.
5. Bhat SK, Raina BL, Chogtu SK, Muthoo AK. Effect of exogenous auxin application on fruit drop and cracking of litchi (*Litchi chinensis* Sonn.) cv. Dehradun. Advances in Plant Sciences.1997;10:83-86.
6. Brahmachari VS, Rani R. Effect of growth substances on fruit drop, yield and physico-chemical composition of litchi fruits. Progressive Horticulture. 2001; 32:50-55.
7. Chang JC, Lin TS. GA_3 increases fruit weight in Yu Her Pau litchi. Scientia Horticulturae. 2006;108:442-443.
8. Awasthi RP, Tripathi BR, Singh A. Effect of foliar sprays of zinc on the fruit drop and quality of the litchi. Punjab Horticulture Journal. 1975;15(3):14-16.
9. Menzel CM, Simpson DR. Lychee cultivars: description and performance of major litchi cultivars in sub-tropical Queensland. Queensland Agricultural Journal. 1986;112(3):126-136.
10. Fivaz J, Robbertse PJ. Floral biology and fruit drop in some litchi varieties. Yearbook of South African Litchi Growers Association. 1995;7:26-30.
11. Noggle GR, Fritz GT. Introductory Plant Physiology, Prentice Hall of India Private Limited Publication, New Delhi. 1989;4.
12. Adams PA, Montague MJ, Tepfer M, Rayle DL, Ikuma H, Kaufman PB. Effect of gibberellic acid on the plasticity and elasticity of *Avena* stem segments. Plant Physiology. 1975;56:757-760.
13. Ram RA, Bose TK. Effect of foliar application of magnesium and micronutrients on growth, yield and fruit quality of mandarin orange (*Citrus reticulata* Blanco.). Indian Journal of Horticulture. 2000;57(3):215-220.
14. Yawalkar KS, Agarwal JP, Bokde S. Manures and fertilizers. 7th Edn., Agri-Horticultural Publishing House, 52, Bajaj nagar, Nagpur-440010, India. 1992;20.
15. Menzel CM, Simpson DR. Lychee nutrition: A review. Scientia Horticulture. 1987; 31:195-224.

16. Gomez AK, Gomez AA. Statistical procedures for agricultural research. 2nd edn. Wiley India Private Limited, Ansari road, Daryaganj, New Delhi. 1984;134-138.
17. Kumar J, Kumar R, Rai R, Mishra S. Response of Pant Prabhat guava trees to foliar sprays of zinc, boron, calcium and potassium at different plant growth stages. The Bioscan. 2015;10(2):495-498.
18. Bowler C, Vancamp W, Van montague M, Inze D. Superoxide-dismutase in plants. Critical Reviews in Plant Sciences. 1994; 13(3):199-218.
19. Singh SD, Singh YV, Bhandari RC. Tomato yield as related to drip lateral spacing and fertilizer application on total and wetted area basis. Canadian Journal of Plant Science. 1989;69:991-999.
20. Brown PH, Bellaloui N, Wimmer MA. Boron in plant biology. Plant Biology. 2002;4:205-223.
21. Khan AS, Ullah W, Malik AU, Ahmed R, Saleem BA, Rajwana IA. Exogenous applications of boron and zinc influence leaf nutrient status, tree growth and fruit quality of Feutrells Early (*Citrus reticulata* Blanco). Pakistan Journal of Agricultural Sciences. 2012;49(2):113-119.
22. Meena D, Tiwari R, Singh OP. Effect of nutrient spray on growth, fruit yield and quality of aonla. Annals of Plant and Soil Research. 2014;16(3):242-245.
23. Dhurve MK, Sharma TR, Bhooriya MS, Lodha, G. Effect of foliar application of zinc and boron on growth, reproductive and yield of pomegranate cv. Ganesh in Hast bahar. International Journal Chemical Studies. 2018;6(5):499-503.
24. Young TW, Harkness RW. Flowering and fruiting behavior of Brewster lychees in Florida. Proceedings of Florida State Horticultural Society. 1961;74:358-363.
25. Davenport TL. Processes influencing floral initiation and bloom; the role of phytohormones in a conceptual flowering model. Horticultural Technology. 2000; 10(4):733-739.
26. Sultana S, Das S, Das B, Rudra BC. Evaluation of various plant growth regulators in flower and fruit setting of litchi. International Journal of Green Pharma. 2016;10(4):242-244.
27. Kaur S. Effect of micronutrients and plant growth regulators on fruit set, fruit retentions, yield and quality attributes in litchi cv. Dehradun. Chemical Science Review and Letters. 2017;6(22):982-986.
28. Dixit A, Shaw SS, Pal V. Effect of micronutrients and plant growth regulators on fruiting of litchi. HortFlora Research Spectrum. 2013;2(1):77-80.
29. Singh A, Yadav AL, Singh JP, Viswakarma G. Effect of foliar spray of nutrients on yield attributing characters of mango (*Mangifera indica* L.). Research in Environment and Life Science. 2015;8(3):469-470.
30. Marboh ES, Singh SK, Pandey S, Nath V, Gupta AK, Pongener A. Fruit cracking in litchi (*Litchi chinensis*): An overview. Indian Journal of Agricultural Science. 2017; 87(1):03-11.
31. Suman M, Sangma PD, Meghawal DR, Sahu OP. Effect of plant growth regulators on fruit crops. Journal of Pharmacognognosy and Phytochemistry. 2017;6(2):331-337.
32. Salisbury FB, Ross C. Plant physiology (ed.) Wadsworth Publishing Company Inc. Belmont, California. 1969;715-747.
33. Haq I, Rab A, Sajid M. Foliar application of calcium chloride and borax enhance the fruit quality of litchi cultivars. Journal of Animal and Plant Science. 2013; 23(5):1385-1390.
34. Singh N, Kaur A, Gill BS. Effect of foliar application of zinc and boron on yield and fruit quality of litchi cv. Dehradun. International Journal of Development Research. 2016;6(7):8686-8688.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/72976