Biological Forum – An International Journal **13(3a): 144-148(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Effect of NAA and Zinc on Fruiting Parameters, Marketable Yield and Quality of Litchi [*Litchi chinensis* (*Gaertn.*) *Sonn.*].

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(Received 30 June 2021, Accepted 07 September, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: An experiment was conducted at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology Kanpur during the year 2020-21. Factorial Completely Randomised Design was used with three replications and sixteen treatments with four levels each of NAA (0, 20, 30 and 40ppm) and Zinc (0, 0.2, 0.4 and 0.6%) and their combination. Spraying was done twice i.e. before flowering and at Pea stage respectively. Sprays of 30ppm NAA significantly maximized length of fruit (3.02cm), fruit diameter (2.76cm), fresh weight of fruit (18.91g), pulp weight (13.00g), marketable yield (68.50 kg/plant), total sugar (13.20%) and TSS (19.46°Brix). Control (N_0) revealed 2.66cm, 2.35cm, 17.51g, 11.46g, 47.08kg/plant, 11.98% and 18.42°Brix values respectively. Zinc applied at 0.4% proved effective and significantly enhanced in length of fruit (3.04cm), fresh weight of fruit (19.09g), pulp weight (13.12g) and TSS (19.60°Brix) over control (Z_0) recorded 2.58cm, 17.33g, 11.42g and 18.16°Brix values respectively. While fruit diameter, marketable yield and total sugar was enhanced due to 0.6% zinc concentration revealing 2.71cm, 63.60 kg/plant and 13.33% respectively, in this regard control (Z_0)exhibited 2.42cm, 55.25kg/plant and 11.69% values respectively. Interactive treatment of N_2Z_2 i.e. 30ppm NAA × 0.4% zinc significantly maximized length of fruit (3.30cm), diameter of fruit (2.99cm), marketable yield (73.11kg/plant), sugar content (14.02%) against control (N_0Z_0) showed the minimum values i.e. 2.46cm, 2.19cm, 44.31kg/plant and 11.46% respectively. Being one of the finest fruit, litchi still need a major attention toward the problems like irregular flowering, poor fruit set, heavy fruit drop, fruit cracking and poor quality to meet the growing demand of national and international market. Therefore, from the experiment, it can be said that the foliar spray of micronutrients and growth regulators were very useful to enhance the yield of litchi orchard significantly.

Keywords: litchi, NAA, zinc, yield, TSS and total sugar.

INTRODUCTION

The litchi [*Litchi chinensis* (*Gaertn.*) Sonn.] is an important subtropical fruit crop considered as non-climacteric fruit, it does not enhance on quality of fruits after harvest but has to ripen on the tree. It is a fruit with sweet translucent and juicy flesh. It has sugar content in different cultivars ranges from 6.74 to 18.86 per cent beside sugar, it has 0.7% pectin, 0.3% fat, 0.7% minerals and Vitamin C 40-60 mg per 100g pulp. Owing to specific climatic requirement the successful cultivation of litchi is restricted to very few countries in the world. India and China accounts for 91% of the world litchi production. India is the second largest producer of litchi next to china. It is grown in sub-mountainous districts of Uttar Pradesh i.e. Saharanpur and Muzaffarnagar (Singh and Singh, 1954). Muzaffarpur of Bihar grows best quality litchi fruits. The litchi fruits also known as "Natural rasgulla" are considerably rich in the sugar. It can be processed into juice, wine, pickles, jam, jelly, ice cream and yoghurt **(**Huang *et al*., 2005). Physiological maturity is essential for quality and shelf life. It comes to the market in the months of May-June when the market is full of other fresh fruits. But, inspite of the availability of different types of fruit in the market, the demand for fresh litchi is always very high due to its unique taste, flavour and colour (Hossain *et al.*, 2014). The fruits after harvest are very perishable and rapidly loose quality of fruits. Micronutrients especially boron, zinc and copper in horticultural crops having paramount importance. Yellowing of citrus, rosetting (little leaf), exanthema or dieback, cracking and hard fruits have been attributed to the deficiency of boron. As like this zinc activated many enzymes in metabolism, zinc is also an essential component of proteinases and peptidases enzyme system. The RNA and ribosome contents in the cells are greatly reduced under zinc deficiency. It enhances flowering, fruit size, growth and quality of fruits. Auxin

greatly affects the respiration, activating role of photo synthesis thereby improving growth. The auxin may increase the osmotic pressure of the cell sap which will induced water uptake and growth. It also changes main quality of the fruits (Gardner, 1951). In view of these importance of zinc and NAA in litchi experiment was planned.

MATERIALS AND METHOD

The present experiment was conducted at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology Kanpur during the year (2020-21). The experiment was planned with sixteen treatments i.e. N_0Z_0, N_0Z_1, N_0Z_2, N_0Z_3, N_1Z_0, N_1Z_1, N_1Z_2, N_1Z_3, N_2Z_0, N_2Z_1, N_2Z_2, N_2Z_3, N_3Z_0, N_3Z_1, N_3Z_2, N_3Z_3 were taken for testing the efficacy of treatments along with three controls *i.e.* N_0, Z_0, and N_0Z_0 and four concentration of NAA (0, 20, 30 and 40ppm) and Zinc (0, 0.2, 0.4 and 0.6%) and their combination replicating thrice in a Factorial Completely Randomised Design. Uniform and healthy sixteen plants of litchi cv. Rose scented were selected and on each plant with similar three branches were identified and that were used as a plot unit. Each branch was allotted for one treatment by using randomization. Different levels of NAA as well as zinc sprays were done twice: first before flower initiation (2 February 2020) and second at pea stage (1 April 2020). All the manurial requirement, cultural practices and plant protection measures were adopted according to norms. Five panicles in each direction were selected randomly in each treatment for recording fruiting and yield observation. Observations to be recorded length of fruit, fruit diameter, fresh weight of fruit, pulp weight, marketable yield, total sugar and TSS. Yield of the fruit was determining to the weighing of fruit with electronic balance in per plant harvested weight of fruits is added and the yield was obtained. The TSS content was determined with hand refractometer and total sugar was estimated according to AOAC (1980). The length and diameter was determined with the vernier callipers, fresh weight and pulp weight of fruit was determined with the help of electronic balance. Recorded T.S.S. sample fruits of each plant were crushed to form a homogenized sample and then the juice was extracted through muslin cloth. The extract was used for determination of T.S.S. in °Brix by hand refractometer. A few drops of juice were placed on the surface of prism. The hinged part was placed back. The refractometer was then reading was noted by resolving the eyepiece at room temperature.

RESULT AND DISCUSSION

The data concern are presented in Tables 1-7.

Length and diameter of fruit (cm): Length and diameter of fruit were significantly maximized (3.02cm) and (2.76cm) under treatment of 30ppm NAA followed by NAA 40ppm (2.95cm and 2.71cm) over control (N_0) recorded 2.66cm and 2.35cm values respectively. The superiority on the size of fruit caused by NAA treatment might be due to its involvement in cell division, cell elongation and increased intracellular spaces in the parenchymal cells which could have boosted plant health and thereby increased fruit size. These findings are in line with the reports of Chaudhary *et al*., (2018) in aonla and Sahay *et al.,* (2018) in litchi. 0.4% concentration of zinc significantly enhanced (3.04cm) fruit length while 0.6% zinc treatment significantly induced (2.71cm) diameter of fruit over control (Z_0) noted 2.58cm and 2.42cm length and diameter respectively. Micronutrient zinc play a significant role in enhancing fruit size and it may be attributed to its doses whose involvement boosted elongation and expansion of cells caused improvement in size of litchi fruits. These findings are in agreement with the reports of Singh *et al*., (2007) in litchi and Yadav *et al.,* (2006) in ber. Interactive treatment of N_2Z_2 significantly revealed maximum of 3.30cm and 2.99cm length and diameter of fruits followed by N_2Z_3 recorded 3.23cm and 2.89cm values over control N_0Z_0 noted 2.46cm and 2.19cm length and diameter respectively.

Fresh weight and pulp weight of fruit: NAA 30ppm significantly increased the maximum of 18.91 and 13.00g fresh weight and pulp weight of litchi fruit respectively followed by treatment of NAA 40ppm showed 18.77 and 12.86g fresh weight and pulp weight of fruit against control (N_0) recorded 17.51 and 11.46g values respectively. The enhancement in fruit weight due to the application of NAA might be the fact that NAA may have induced the auxin concentrations in the fruits which finally helped in the development of fruits as there is perceptible correlation between the NAA content and fruit growth (Ghosh *et al.,* (2009) in aonla). These findings are in accordance with the reports of Yadav *et al.,* (2010) in aonla, Dutta *et al*., (2011); Sahay *et al*., (2018) in litchi. As regard pulp weight there is some evidence i.e. auxin influences cell wall and thus, increasing its flexibility and plasticity. This would allow stretching of cell wall along with greater water uptake increasing cell size which ultimately promoted pulp weight in fruit. These findings are in line with the reports of Sharma and Dhillon, (1987) in litchi, Singh *et al.,* (2007) in aonla. Maximum of 19.09 and 13.12g fresh weight and pulp weight of fruit were recorded under 0.4% zinc followed by 0.6% zinc dose revealing 19.07 and 13.05g values respectively over control (Z_0) exhibited 17.33 and 11.42g respectively. Application of zinc in moderate concentration enhanced fruit weight considerably due to more accumulation of sugar and extended juice percentage in zinc treated fruits. These findings are in agreement with the reports of Saraswat *et al*., (2006); Katiyar *et al.,* (2008) in litchi. As for as weight of Pulp, zinc sprays act as acceleration of pulp weight and this appreciable increase might be due to enhancing water absorption and solutes thereby mobilization of sugar in cells increasing ultimately pulp weight. These findings are in accordance with the reports of Sharma and Dhillion, (1987); Kaur *et al.,* (2017) in litchi. Interactive effect of NAA × zinc did not exhibit significant variation on fresh weight and pulp weight of fruit respectively.

Marketable yield per plant (kg): Significantly highest yield 68.50kg/plant was noted under the treatment of NAA 30ppm followed by NAA 40ppm (64.37 kg) over control N_0 (47.08kg). Maximum of 45.50%

improvement was recorded due to 30ppm NAA dose over control. The improvement brought about by NAA may be attributed to its physiological activities in the plants which could have checked fruit drop, reduced fruit cracking and minimized number of blemished fruits considerably thereby increasing yield as well as marketable yield. The findings are in line with the reports of Ghosh *et al.,* (2009); Yadav *et al.,* (2010) in aonla, Chauhan *et al*., (2019) in litchi. 0.6% zinc dose significantly maximized (63.60kg) marketable yield followed by its 0.4% dose (62.93 kg) over control Z_0 (55.25kg). The marketable yield fluctuated in the tune of 55.25 to 63.60 kg showing the improvement by 15.11% due to 0.6% zinc dose over control. Zinc helps in translocation of metabolites from source to sink which enhance to retention of more number of the fruits on the tree which ultimately promoted the yield of fruits in plants. These findings are in accordance with the reports of Singh *et al*., (2015) in mango, Saraswat *et al*., (2006); Chauhan *et al*., (2019) in litchi. Significantly maximum of 73.11 kg/plant marketable yield was noted under the interactive treatment N_2Z_2 followed by N_2Z_3 (71.62 kg) over control N_0Z_0 (44.31kg). The improvement on yield due to interactive treatment N_2Z_2 increased 65% over control (N_0Z_0). These findings are in agreement with the reports of Saraswat *et al.*, (2006); Chauhan *et al*., (2019) in litchi and Dutta and Banik (2007) in Guava.

Fruit quality (total sugar and total soluble solids):

Total sugar percentage: NAA sprays greatly influence on Sugar content in litchi fruits and its 30ppm concentration revealed significantly maximum of 13.20% total sugar content in litchi fruits followed by NAA 40ppm(12.99%) over untreated plant i.e. control N_0(11.98%). There was an improvement in increased by 10.18% due to NAA 30ppm concentration over control. The superiority brought about by NAA treatment may be attributed to the fact that growth regulators promoted hydrolysis mechanism of starch into sugar or reduce competition between the fruits form metabolites. The increase in total sugar may be attributed further to conversion of reserve starch and other polysaccharides into soluble form of sugar. These findings are similar with the accordance of Ghosh *et al*., (2009); Yadav *et al.,* (2010) in aonla, Saraswat *et al*., (2006); Dutta *et al*., (2011) in litchi. Zinc significantly induced the maximum of 13.33% total sugar under 0.6% zinc dose followed by its 0.4% (13.31%) over control Z_0(11.69%). A ranged of 11.69 to 13.33% was indicated in this regard and there was an enhancement of 14.03% due to sprays of 0.6 % zinc dose over control (Z_0). The possible reason for increase in total sugar in fruit pulp by foliar sprays of zinc might be due to the conversion of starch and acid into sugar in addition to continuous mobilization of Sugars from leaves to fruits. The present findings are in line with the reports of Ghosh *et al.,* (2009) in aonla, Saraswat *et al*., (2006); Priyadarshi *et al.,* (2018) in litchi. Interactive treatments N_2Z_2 significantly revealing the maximum of 14.02% total sugar followed by N_3Z_2 (13.80%) over control N_0Z_0 (11.46%). The enhancement of 22.34 and 20.42% on total sugar content obtained respectively due to interactive treatment of N_2Z_2 and N_3Z_2 over control (N_0Z_0). These findings are in agreement with the report of Ghosh *et al*., (2009) in aonla and Saraswat *et al.*, (2006) in litchi.

Total soluble solids: Treatment of NAA 30ppm concentration significantly improved the maximum of 19.46°Brix TSS content in litchi fruits. When efficacy of remained treatments was further examined, the second effective treatment was obtained NAA 40ppm recorded 19.33°Brix TSS. Deprived plants with hormonal treatments i.e. control (N_0) recorded the minimum of 18.42°Brix TSS content. The improvement in TSS with the use of growth regulator NAA might have caused with the diversion of more solid metabolites towards developing fruits increasing amylase activities and thus, there was conversion of starch into simple sugar thereby enhancing total soluble solids content in fruits. The findings are in accordance with the reports of Yadav *et al.,* (2010) in aonla, Saraswat *et al.,* (2006), Dutta *et al.,* (2011); Dodiya *et al.,* (2018) in litchi. 0.4% zinc dose significantly induced the maximum of 19.60°Brix TSS content closely followed by its higher concentration i.e.0.6% zinc dose revealing 19.52°Brix TSS over control (Z_0) recorded 18.16°Brix TSS content. These results might be attributed to the fact that zinc credited with certain contribution in the hydrolysis of complex polysaccharides into simple sugar, synthesis of metabolites and fast translocation of photosynthetic outcome and due to movement of minerals from one part to another part in the plants might be caused to enhancing TSS contents in fruits. The present results are in line with the reports of Rawat *et al.,* (2010) in guava, Saraswat *et al*., (2006); Katiyar *et al.,* (2008) in litchi. Interactive effect of NAA × zinc did not exhibit significant variation but further improvement was observed numerically and interactive treatment N_2Z_2 produced maximum of 20.16 °Brix over control (N_0Z_0) noted 17.66°Brix TSS content.

Table 1: Effect of foliar sprays of zinc and NAA, their interactions on length of fruit of litchi (cm).

Treatments	Z_0 Zinc	Z_1 (0.2%) Zinc	Z_2(0.4%) Zinc	Z_3 (0.6%) Zinc	Mean	C.D S.E.
N_0 NAA	2.46	2.61	2.79	2.80	2.66	N-0.06 0.031
N_1 (20 ppm) NAA	2.56	2.71	2.86	2.89	2.75	Z-0.06 0.031
N_2 (30 ppm) NAA	2.68	2.86	3.30	3.23	3.02	(N × Z) Interaction- 0.12 0.061
N_3 (40 ppm) NAA	2.62	2.82	3.20	3.18	2.95	
Mean	2.58	2.75	3.04	3.02		

Table 2: Effect of foliar sprays of zinc and NAA, their interactions on diameter of litchi fruits (cm).

Treatments	Z_0 (0%) Zinc	Z_1 (0.2%) Zinc	Z_2 (0.4%) Zinc	Z_3 (0.6%) Zinc	Mean	C.D. S.E.
N_0 (0%) NAA	2.19	2.38	2.40	2.45	2.35	N-0.04 0.019
N_1 (20 ppm) NAA	2.47	2.56	2.58	2.68	2.57	Z-0.04 0.019
N_2 (30 ppm) NAA	2.51	2.67	2.99	2.89	2.76	(N × Z) Interaction- 0.08 0.039
N_3 (40ppm) NAA	2.51	2.67	2.84	2.83	2.71	
Mean	2.42	2.57	2.70	2.71		

Table 3: Effect of foliar sprays of zinc and NAA, their interaction on fresh weight of fruits (g).

Treatments	Z_0 (0%) Zinc	Z_1 (0.2%) Zinc	Z_2 (0.4%) Zinc	Z_3 (0.6%) Zinc	Mean	C.D. S.E.
N_0 (0%) NAA	16.40	17.24	18.10	18.31	17.51	N-0.62 0.306
N_1 (20 ppm) NAA	17.60	17.77	19.03	19.12	18.38	Z-0.62 0.306
N_2 (30 ppm) NAA	17.74	18.79	19.68	19.45	18.91	(N × Z) Interaction- N.S. 0.612
N_3 (40ppm) NAA	17.57	18.57	19.55	19.39	18.77	
Mean	17.33	18.09	19.09	19.07		

Table 4: Effect of foliar sprays of zinc and NAA, their interactions on pulp weight of litchi fruits (g).

Treatments	Z_0(0%) Zinc	Z_1(0.2%) Zinc	Z_2(0.4%) Zinc	Z_3(0.6%) Zinc	Mean	C.D. S.E.
N_0 (0%) NAA	10.25	11.15	12.16	12.27	11.46	N-0.26 0.128
N_1 (20 ppm) NAA	11.60	11.94	13.01	13.08	12.41	Z-0.26 0.128
N_2 (30 ppm) NAA	11.98	12.80	13.73	13.49	13.00	(N × Z) Interaction- N.S. 0.255
N_3 (40 ppm) NAA	11.87	12.63	13.58	13.36	12.86	
Mean	11.42	12.13	13.12	13.05		

Table 5: Effect of foliar sprays of zinc and NAA, their interaction on marketable yield per plant (kg/plant).

Treatments	Z_0 Zinc	Z_1 (0.2%) Zinc	Z_2 (0.4%) Zinc	Z_3(0.6%) Zinc	Mean	C.D. S.E.
N_0 NAA	44.31	46.41	48.16	49.44	47.08	N-1.75 0.858
N_1 (20 ppm) NAA	57.28	59.65	63.68	67.87	62.12	Z-1.75 0.858
N_2 (30 ppm) NAA	59.48	69.81	73.11	71.62	68.50	(N × Z) Interaction- 3.50 1.716
N_3 (40 ppm) NAA	59.94	65.30	66.78	65.47	64.37	
Mean	55.25	60.29	62.93	63.60		

Table 6: Effect of foliar sprays of zinc and NAA, their interactions on total sugar (%).

Treatments	Z_0 (0%) Zinc	Z_1(0.2%) Zinc	Z_2 (0.4%) Zinc	Z_3 (0.6%) Zinc	Mean	C.D. S.E.
N_0 (0%) NAA	11.46	11.54	12.34	12.58	11.98	N-0.10 0.047
N_1 (20 ppm) NAA	11.71	12.12	13.09	13.36	12.57	Z-0.10 0.047
N_2 (30 ppm) NAA	11.88	13.13	14.02	13.76	13.20	(N×Z) Interaction- 0.19 0.094
N_3 (40 ppm) NAA	11.73	12.78	13.80	13.64	12.99	
Mean	11.69	12.39	13.31	13.33		

Table 7: Effect of foliar sprays of zinc and NAA, their interactions on total soluble solid (TSS) content in litchi fruits (°Brix).

Treatments	Z_0 (0%) Zinc	Z_1 (0.2%) Zinc	Z_2 (0.4%) Zinc	Z_3 (0.6%) Zinc	Mean	C.D. S.E.
N_0 (0%) NAA	17.66	18.19	18.87	18.98	18.42	N-0.14 0.068
N_1 (20 ppm) NAA	18.12	18.64	19.36	19.53	18.91	Z-0.14 0.068
N_2(30 ppm) NAA	18.51	19.29	20.16	19.88	19.46	(N × Z) Interaction- N.S. 0.135
N_3 (40 ppm) NAA	18.34	19.25	20.01	19.71	19.33	
Mean	18.16	18.84	19.60	19.52		

CONCLUSION

On the basis of results obtained in present investigation it is concluded that individual application of NAA and zinc brought about significant changes in plant metabolism. NAA 30ppm improved fruit set, fruit retention, length of fruit, diameter of fruit, fresh weight of fruit, pulp weight, rind weight, marketable yield, total sugar and TSS content. It's also minimized important desired characters i.e. cracked fruits and fruit drop. Zinc 0.4% dose was found more effective on enhancing fruit set, fruit retention, length of fruit

weight, weight of fresh fruit, pulp weight, marketable yield and TSS content and it's also minimized fruit drop, cracked fruit and seed weight. NAA 30ppm in association with 0.4% zinc was more effective on length, diameter of fruit and rind weight, marketable yield, sugar content and TSS content and it also minimized cracked fruits in litchi. Thus, in view of the above achievements 30ppm NAA in consumption with 0.4% zinc may be recommended safely to the Litchi growers for increasing quality and yield of Litchi fruits. The above recommendations adopted systematically and correctly, possess the potentiality of improving economic and prosperity of the country.

Acknowledgement. The experiment was supported by my Advisor Dr. J. P. Singh and all faculty members of Department of Fruit Science, College of Horticulture, CSA University of Agriculture and Technology, Kanpur 208002, (U.P.) for providing us necessary facilities to undertake the studies.

Conflict of Interest. Nil.

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How to cite this article: Gautam, S., Singh, J.P., Kumar, S. and Yadav, S. (2021). Effect of NAA and Zinc on Fruiting Parameters, Marketable Yield and Quality of Litchi [*Litchi chinensis (Gaertn.) Sonn.*]. *Biological Forum – An International Journal, 13*(3a): 144-148.