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Influence of GA_3, Zinc and Boron on Fruit drop, Yield and Quality of Litchi (*Litchi chinensis* Sonn.)

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ABSTRACT: An experiment was conducted during the year 2022 to study the influence of GA_3, zinc and boron on fruit drop, fruit cracking, yield and quality of litchi. For this ten treatments *viz.*, three level each of GA_3 (25, 50 and 75 ppm), $ZnSO_4$ (0.2, 0.4 and 0.6 %) and borax (0.2, 0.4 and 0.6 %) along with one control, replicated thrice in RBD were used for the experimental work. The recommended dose of fertilizers along with other horticultural and agronomic operations was applied in all treatments including control. The plant bio-regulator and mineral nutrients were sprayed twice on the tree, once before flowering on 05/02/2022 and secondly again at pea stage offruits on 15/03/2022 with a sprayer having a very fine nozzle. The foliar application of micronutrients along with plant bio-regulators plays an important role in manipulating many physiological phenomena, improving the yield and quality and enhanced the productivity of plants by fulfilling the nutritional needs of fruit crops. The utilization of boron helps in the movement of sugar and advances fruit bud formation. From the experiment, it is reported that the spraying of borax at 0.4 % resulted minimum fruit drop (69.45%), fruit cracking (4.63 %), reduced weight of seed (2.30 g) and gave maximum fruit retention (30.55%), fruit sets (62.50 %), fruit length (4.50 cm) and width (3.96 cm), weight (24.85 g), weight of pulp (20.73 g), fruit pulp: seed ratio (5.50 %), fruit yield (120.85 kg/plant), total soluble solids (22.55ºBrix) and total sugars (18.42 %) with minimum percentage of titratable acidity (0.41%) under plains of central Uttar Pradesh.

Keywords: Litchi, GA_3, $ZnSO_4$, Borax, Fruit drop, Yield and Quality.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is a tasty and juicy fruit of exceptional quality. Botanically it belongs to the family Sapindaceae and sub-family Nepheleae, containing around 150 genera and 2000 species, having chromosome number 2n=30. It is native of South China and widely cultivated for its valued fruit even before 1766 B.C. in China. Because of explicit climatic prerequisites, the successful cultivation of litchi is limited to very few nations of the world. India is the second-biggest producer of litchi next to China. Besides China and India, other significant litchi-growing nations are West Indies, Brazil, Hawaii, Madagascar, Southern Japanand Spain, etc. The litchi is one of the most environmentally sensitive fruit trees. Fruit cracking is a widespread issue for several fruits such as litchi, citrus, grapes, date palm, pomegranate and cherry etc., and losses due to this problem are sometimes as high as 75%. The cracked fruits decay rapidly and are not valued for selling.

Gibberellin is principally utilized for controlling numerous physiological events and is commercially used to improve the quality of fruits, whereas, zinc activated numerous enzymes in metabolism. Zinc is additionally a fundamental part of the proteinases and peptidases enzymes system. Zinc is used to induce early blossoming, improving size, growth and quality in many fruits. Boron, on the other hand, is considered fundamental for hormone metabolism, photosynthetic activities, cellular differentiation and water absorption in plant parts. It is also involved in reproduction, germination of pollen tubes and fertilization, therefore, keeping in view, the importance of these plant bio-regulator and micronutrients the present experiment was planned to infer concrete information on the effect of these in respect of fruit drop, fruit cracking, yield and quality in litchi.

MATERIALS AND METHODS

Forty-two years old but properly maintainedplants of the litchi cv. Rose Scented were selected for the purpose of the experimentationin the garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur-208002 (U.P.), India, during the year 2022. There were ten treatments *viz.*,three level each of GA_3 (25, 50 and 75 ppm), $ZnSO_4$ (0.2, 0.4 and 0.6 %) and borax (0.2, 0.4 and 0.6 %) along withone control, replicated thrice in RBD were used for the experimentation work. The recommended dose of fertilizers was applied in all treatments including control. The plant bio-regulator and mineral nutrients were sprayed on the treetwice, once before flowering on 05/02/2022 and secondly again at the pea stage offruit on 15/03/2022 with a sprayer having a very fine nozzle. The detergent powder was well mixed in the spray solution which act as a sticker before spraying. The information recorded on different parameters during experimental period was statistically analyzed.

Observations on fruit drop, fruit retention, fruit set and fruit cracking percentages were recorded during the fruiting season. At each picking, data on fruit weight and yield per plant were recorded. The length and width of ten randomly selected fruits were measured with the help ofvernier calliper and expressed in cm. Data on weight of pulp, weight of seed andpulp/seed ratio were also recorded.The TSS of fruitswas recorded with the assistance of Erma hand refractometer. The titratable acidity and total sugars contents were determined by the techniques suggested in AOAC (1980).

RESULTS AND DISCUSSION

Fruit drop and retention. With the foliar application of plant bio-regulator and micro-nutrients significantly reduced fruit drop with increased fruit retention were observed during the experimentation period. The minimum fruit drop (69.45%) and maximum fruit retention (30.55%) was noted under borax 0.4 % followed by borax 0.6 % (71.54 and 28.46%, respectively), GA_3 75 ppm (72.19 and 27.81%, respectively) and $ZnSO_4$ 0.6 % (73.78 and 26.22%, respectively) treated plants, whereas, maximum fruit drop (78.96%) and minimum fruit retention (21.04 %) was recorded in plants kept under control (Table 1). The spraying of plants with Borax was found more effective than GA_3 and $ZnSO_4$ in controlling fruit drops and increasing fruit retention.

Table 1: Influence of GA_3, Zinc sulphate and borax on fruit set, drop, retention, cracking and physical fruit parameters inlitchi cv. Rose Scented.

Treatments	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Fruit cracking (%)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)
GA_3 @ 25 ppm	57.54	76.82	23.51	12.14	3.67	3.44	20.68
GA_3 @ 50 ppm	59.80	75.85	24.15	12.02	3.61	3.41	23.36
GA_3 @ 75 ppm	60.35	72.19	27.81	11.62	3.74	3.59	22.80
$ZnSO_4$ @ 0.2%	55.67	77.38	22.62	12.27	3.49	3.51	20.89
$ZnSO_4$ @ 0.4%	56.85	76.54	23.41	10.61	3.62	3.64	22.39
$ZnSO_4$ @ 0.6%	58.45	73.78	26.22	10.46	3.54	3.32	21.56
Borax @ 0.2%	58.15	74.85	25.15	9.83	3.85	3.39	22.89
Borax @ 0.4%	62.50	69.45	30.55	4.63	4.50	3.96	24.85
Borax @ 0.6%	61.80	71.54	28.46	4.90	3.97	3.74	23.80
Control (Water spray)	46.85	78.96	21.04	16.41	3.10	2.85	18.50
S.E.(m)±	0.67	0.71	0.71	0.42	0.05	0.04	0.24
CD at 5%	2.01	2.14	2.13	1.26	0.15	0.14	0.72

This increase in fruit retention and reduction in fruit drop of litchi fruits might be due to the reason that borax and zinc sulphate isalso an important part of the cell wall (middle lamella) of plant cells along with calcium pectate which plays an important role in the strengthening of pedicel attached to the proximal end of fruit which resulted in less fruit drop. Similarly,the reduction in fruit drop by the spray of borax may also be due to the indirect action of boron in auxin synthesis that delayed the formation of the abscission layer during the early stages of fruit development, which ultimately increases fruit retention percentage. These findings align with the result of Saraswat *et al.* (2006); Chauhan *et al.* (2019) in litchiand Tripathi *et al.* (2018) in aonla.

Fruits Set. From the present investigation (Table 1), it is observed that the number of fruit sets per plant increased significantly with the use of plant bio-regulator and micronutrients. The maximum number of fruits set was obtained in plants treated with borax 0.4 % (62.50 %) followed by borax 0.6 % (61.80 %), GA_3 75 ppm (60.35 %) and $ZnSO_4$ 0.6 % (58.45 %), whereas, the minimum fruit set (46.85 %) was recorded in the plant which was kept under control.

This increase in fruit set with borax and zinc application might be due to its effect on the process of fertilization and hormonal (GA_3) metabolism, which proved helpful in maintaining the better nutritional status of the tree and ultimately proved beneficial in improving the fruit set. These findings agree with the result of Chauhan *et al.,* (2019); Das *et al.,* (2020) in litchi.

Fruit Cracking. The data presented in Table 1, clearly revealed that the minimum fruit cracking (4.63 %) was observed in fruits which were produced from the plants treated with borax at 0.4 %concentration which was followed by borax 0.6 % (4.90 %), GA_3 75 ppm (11.62 %) and $ZnSO_4$ 0.6 % (10.46 %), whereas, the maximum fruit cracking (16.41 %)was recorded in plants which were produced from the plant kept under control. The spraying of borax was found more effective than GA_3 and $ZnSO_4$. It is well known that borax and zinc spray regulate auxin in the plants which might have increased the synthesis of tryptophan and indirectly also regulated water relations in plants. The application of auxin might have increased the osmotic pressure of the cell sap, which will induce water uptake and reduce the cracking percentage in fruits. The findings are following the reports of Kaur (2017); Chauhan *et al.* (2018) in litchi**.**

Physical Parameters

Fruit Size. The size of fruits were recorded by measuring of fruits with vernier callipers and average value was obtained. The application of borax significantly influenced the size of litchi fruits and maximum length (4.50 cm) and width (3.96 cm) were observed with borax 0.4 % followed by borax 0.6 % (3.97 and 3.74 cm, respectively), GA_3 75 ppm (3.74 and 3.59 cm, respectively) and $ZnSO_4$ 0.4 % (3.62 and 3.64 cm, respectively), whereas, the minimum fruit length (3.10 cm) and width (2.85 cm) was recorded in fruits which were produced from the plants which were kept under control *i.e.*, without application of non-amount of plant bio-regulator and micronutrients (Table 1).

This improvement in fruit size can thus be attributed due tothe greater mobilization of food materials fromthe site of their production to the storage organsunder the influence of applied micronutrients. Since boron plays an important role in nitrogen metabolism and other changes in fruits, thus it might have increased the fruit size. The results are in agreement with the findings of Singh *et al.* (2009) in aonla and Shukla *et al.* (2011) in aonla cv. NA-7.

Fruit Weight. Fruit weight was significantly influenced by the foliar application of plant bio-regulators and micro-nutrients. The significantly maximum weight of fruit was recorded which were produced from the plants treated with the application of borax 0.4 % (24.85 g) followed by GA_3 50 ppm (23.36 g) and $ZnSO_4$ 0.4 % (22.39 g) which are significantly higher than all other treatments, whereas, the fruits of minimum weight (18.50 g) was produced from the plants which were kept untreated as control (Table 1).

Litchi is indehiscent nut fruit, in which the tubercles develop from the wall of the ovary from which hair had fallen off after fertilization. Fruits generally develop from one locule of the ovary due to enlargement of the cells of the mesocarp. In the present investigation fresh weight of fruits was promoted significantly with the application of GA_3, zinc sulphate and borax as compared to their control. As regards borax and zinc are concerned, these play a positive role in nucleoprotein, amino acids, amino sugars and many other compound formation in plant system. This would allow stretching of the cell wall along with greater water uptake and increased cell size which ultimately increase the size of fruits being directly responsible for the increase in weight of fruit also. These investigations get support from the findings of Mishra *et al.* (2012) in mango and Kaur (2017) in litchi.

Fruitpulp and Seed Weight. Significantly improved fruit pulp and reduced seed weight were recorded with the foliar application of plant bio-regulator and micro-nutrients. Significantly more weight of pulp (20.73 g) and reduced weight of seed (2.30 g) in fruits were recorded, which were harvested from the plants treatedwith borax 0.4 % closely followed by GA_3 50 ppm (18.14 and 3.13 g, respectively) and $ZnSO_4$ @ 0.4 % (17.14 and 3.11 g, respectively), whereas, the fruits with minimum pulp weight (11.36 g)and maximum weight of seed (3.96 g) were produced from the untreated control plant (Table 2). The remaining other treatments also significantly increase pulp content and reduced seed weight in the fruits as compared to the control.

Table 2: Influence of GA_3, Zinc sulphate and borax on physio-chemical parameters of litchi cv. Rose Scented.

Treatments	Pulp weight (g)	Weight of seed (g)	Pulp: seed ratio	T.S.S. (°Brix)	Total sugar (%)	Titratable acidity (%)
GA_3 @ 25 ppm	15.30	3.16	4.25	17.57	15.18	0.48
GA_3 @ 50 ppm	18.14	3.13	4.39	19.60	17.09	0.44
GA_3 @ 75 ppm	16.74	3.36	4.48	18.67	15.69	0.46
$ZnSO_4$ @ 0.2%	15.25	3.50	4.14	20.34	16.59	0.45
$ZnSO_4$ @ 0.4%	17.14	3.11	4.39	18.73	15.10	0.47
$ZnSO_4$ @ 0.6%	16.35	3.16	4.42	19.49	15.35	0.46
Borax @ 0.2%	17.64	3.24	4.37	19.69	16.22	0.43
Borax @ 0.4%	20.73	2.30	5.50	22.55	18.42	0.41
Borax @ 0.6%	17.86	3.23	4.67	21.36	17.11	0.42
Control (Water spray)	11.36	3.96	3.18	16.85	14.60	0.50
S.E.(m)±	0.28	0.09	0.07	0.22	0.21	0.00
CD at 5%	0.85	0.28	0.21	0.66	0.64	0.02

This increase in fruit pulp content and reduced seed weight with the application of boron might be due to the reason that borax plays an important role in overcoming the boron deficiency in fruits and hence the application of borax might have overcome the boron deficiency, which in turn caused maximum pulp content. Boron is an essential nutrient that is involved in several physiological processes in fruit, involving in the maintenance of cell wall integrity and upto some extent found inhibiting the senescence of litchi fruits. These results are in concurrence with Saraswat *et al.* (2006) in litchi, Singh *et al.* (2017) in mango and Kaur (2017) in litchi.

Pulp: Seed Ratio. Fruit pulp: seed ratio was significantly higher in fruits which were produced from the plants which were sprayed with borax 0.4% (5.50 %) followed by borax 0.6 % (4.67 %), GA_3 75 ppm (4.48 %) and $ZnSO_4$ @ 0.6 % (4.42 %). The minimum pulp: seed ratio (3.18 %) was obtained in fruits which were produced from the control plants (Table 2). This improvement in pulp: seed ratio may be due to more accumulation of food substances in elongated cells and intercellular space of mesocarp.

The scenario of the above findings on pulp: seed ratio showed the prominent influence of borax rather than GA_3 and zinc sulphate in promoting pulp: seed ratio. It might be due to the faster-leading mobilization of sugars into the fruit and increasing intercellular space in the pulp.

Borax also plays important role in hormonal metabolism and photosynthesis and cellular differentiation and water absorption in plant parts and this in the present study would have manipulated pulp and seed weight and ultimately their ratio. The findings are following the reports of Saraswat *et al.* (2006) in litchi; Singh *et al.* (2017) in mango and Kaur (2017) in litchi.

Fruit Yield. In litchi, the period of fruiting is characterized by high temperature, strong winds and extremes of soil moisture and humidity, but the effects of the environment have been examined superficially. Fruit yield (kg/plant) was significantly influenced by the foliar application of plant bio-regulator and micronutrients as compared to control. The plants sprayed with borax 0.4 % produced highest fruit yield (120.85 kg/plant) followed by borax 0.6 % (118.65 kg/plant), GA_3 50 ppm (107.50 kg/plant) and $ZnSO_4$ 0.4 % (112.56 kg/plant). The minimum yield (77.30 kg/plant) was obtained in control plants (Fig. 1).

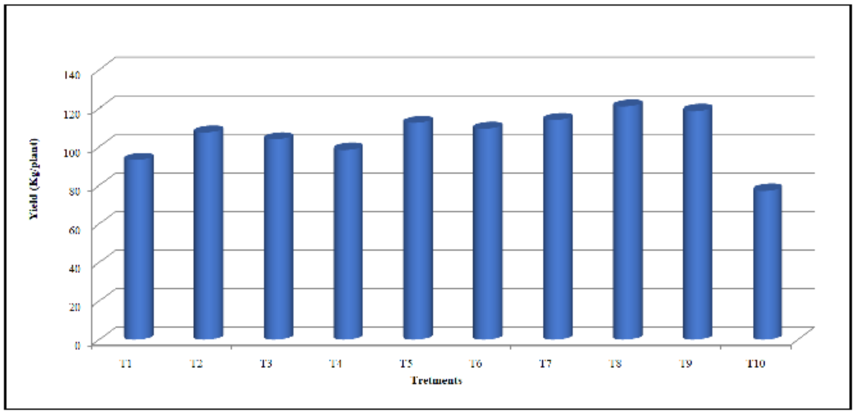

Fig. 1. Influence of GA_3, Zinc sulphate and borax on yield (kg) per plant in litchi cv. Rose Scented.

This increase in yield with bio-regulator and micronutrients application proved highly helpful in increasing photosynthesis, mobilization of food material and accumulations of quality constituents promoting the physical attribute like fruit weight and size which ultimately increase the fruit yield. These findings are similar to the reports of Singh *et al.*, (2017) in mango and Chauhan *et al.* (2019) in litchi, Chaturvedi, *et al.* (2005) in strawberry, Badal and Tripathi (2021) in guava.

Chemical Parameters

TSS, Total Sugars and Titratable Acidity. Data presented in Table 2 revealed that the maximum total soluble solids (22.55ºBrix) and total sugars (18.42 %) contents were recorded in the fruits which were produced from the plants treated with borax 0.4 % followed by $ZnSO_4$ 0.2 % (20.34°Brix and 16.59 %, respectively). This increase in TSS and total sugars content with borax and zinc application might be due to their increased active role in the mobilization of food material leading to the accumulation of quality constituents like carbohydrates which ultimately promoted the quality attributes. These findings are align with the results of Kaur (2017) in litchi, Singh *et al.* (2017) in mango and Chaturvedi *et al.* (2005) in strawberry.

Titratable acidity content in fresh fruits was decreased by the application of plant bio-regulator and micronutrients. The minimum percentage of titratable acidity was found in the fruits which were produced from the plants treated with borax @ 0.4 % (0.41 %) closely followed by borax @ 0.6 % (0.42 %), whereas, the maximum titratable acidity contents (0.50 %) were recorded in fruits which were produced from untreated (control) plants. These findings are in accordance with the results of Kaur (2017) and Singh *et al.*, (2018) in litchi and Singh *et al.* (2017) in mango.

CONCLUSION

From this experiment,it is securely concluded that the use of GA_3, $ZnSO_4$ and borax significantly reduced fruit drop, fruit cracking and increased fruit retention, fruit size, yield and quality attributes in litchi. Spraying of borax at 0.4 % results in minimum fruit drop (69.45%), fruit cracking (2.63 %), reduced weight of seed (2.30 g) along with maximum fruit retention (30.55%), fruits set (62.50 %), fruit length (4.50 cm) and width (3.96 cm), weight (24.85 g), weight of pulp (20.73 g), fruit pulp: seed ratio (5.50 %), fruit yield (120.85 kg/plant), total soluble solids (22.55ºBrix) and total sugars (18.42 %) with minimum percentage of titratable acidity (0.41 %) under plains of central Uttar Pradesh.

FUTURE SCOPE

The use of plant bio-regulator and micro-nutrients assumes a significant part in increasing the yield of quality fruits with the reduction in fruit drop, cracking along with increased fruit retention. Since litchi is an important fruit crop all over the world in sub-tropical climate. That's why in the future, more studies can be carried out on other cultivars alone or in the combination of both *i.e.*, plant bio-regulator and micro-nutrients on more parameters to standardize doses specific to the particular regions.

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Conflict of Interest. None.

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