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Response of Foliar Application of Calcium and Boron on Vegetative and Reproductive Traits of Jackfruit (*Artocarpus heterophyllus* L.)

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Abstract: The investigation was conducted on jackfruit in the Horticulture Research Center, Patharchatta, GBPUAT, Pantnagar, Uttarakhand, India. The experiment involved the three foliar sprays of calcium as calcium carbonate and boron as borax individually and their combination in one month interval starting from flower initiation. The treatments include T_1: calcium carbonate 0.2%, T_2: calcium carbonate 0.4%, T_3: calcium carbonate 0.6%, T_4: borax 0.4%, T_5: borax 0.6%, T_6: borax 0.8%, T_7: calcium carbonate 0.2% + borax 0.4%, T_8: calcium carbonate 0.4% + borax 0.6%, T_9: calcium carbonate 0.6% + borax 0.8%, T_{10}: control. The result indicated that calcium carbonate 0.6% + borax 0.8% increased the annual plant height, annual canopy spread, annual stem girth, annual tree volume, annual cross-sectional trunk area, number of fruit set, per cent fruit set and yield in jackfruit as compared to control. Three sprays of calcium carbonate 0.6%+ borax 0.8% starting from the time of initiation of flowering proved the best treatment in increasing the plant growth and yield of jackfruit.

Keywords: Calcium, boron, growth, fruit set, yield, jackfruit.

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1. Introduction

Jackfruit (*Artocarpus heterophyllus* L.) is one of the most significant and widely grown fruit trees in a tropical region. It belongs to the family Moraceae. Jackfruit is the most important fruit in India and considered to be the largest fruit in the world (Naik, 1949). The estimated production of jackfruit in India was 1815 thousand MT from an area of 187 thousand hectares (Anonymous, 2018-19).

It is widely distributed in Assam, Uttar Pradesh, Tripura, West Bengal, Bihar, South Indian states of Kerala, Tamil Nadu and Karnataka and the foothills of the Himalayas. Tender fruits are used for vegetable and pulp of ripe fruits consumed fresh and used for the preparation of several preserves like candies, beverages, jam and another hydrated form in industry. Jackfruit has various health benefits, jackfruit contains vitamin C which helps to protect against viral and bacterial infections, and strengthen the immune system. Jackfruit is also rich in phyto-nutrients such as saponin, isoflavones and lignans which have anti-aging and anti-cancer properties. Jackfruit is also known to cure ulcers and digestive disorders because it contains anti-ulcer properties (Devi *et al*. 2014).

There are many problems in jackfruit like fruit cracking, fruit drop, fruit deformation which affect the quality of fruit and mostly yield. In Uttarakhand people grow this fruit abundantly but they do not get real value for shriveled shape and size. The consumers generally do not like to purchase deformed shaped fruits for which the growers feel discouraged. One of the reasons for dropping of female spikes might be that it generally appears on the trunk and main branches. On the other hand, the male spikes appear in the periphery. Their anthesis period is not also synchronized. So, there is a possibility of improper pollination. If the flowers on all the sides are not pollinated, the fruit does not develop normally as a result the size and shape may be small and irregular. Lack of pollination may also lead to the dropping of the female spikes (Samaddar and Yadav, 1982; Tessy *et al*. 1996a). The number of fruits per tree is dependent on the number of female spikes and the ratio of male to female spikes (Tessy *et al*. 1996b). The final size attained and the shape of the fruit depends on the number of flowers pollinated and fertilized and the pattern of pollination of flowers. Unfertilized flowers also lead to irregular shape of the fruits (Sharma, 1964). Calcium plays a vital role as binding agent in the calcium pectate form in the cell wall (Sharma *et al*. 1996) and about 60% of total calcium associated with cell wall fraction in the plant. Calcium plays an important role in maintaining the quality of fruit and helps to retain fruit firmness, increase vitamin c content, decrease rotting and storage breakdown and also decrease browning in apples. Boron is another important micronutrient involved in cell division, cell wall development, phloem development, and movement of sugars, metabolism of phosphorus and nitrogen and absorption of salts (Dale and Krystyna, 1998). It has been found that B deficiency restricts the germination of pollen grains. Imbalanced fertilization sometimes causes de-pollination. If pollination and fertilization fail to occur within 3-6 days after

anthesis, the fruits become twisted and shriveled in shape (Bose, 1990). Boron may stimulate the normal flow of hormone and enhance pollen grain and pollen tube formation. It also increases the stickiness of the stigma for receiving the pollen grains. Foliar feeding is based on the principle that the nutrient is quickly absorbed by plant leaves and transported to different plant parts to fulfill the functional requirements of nutrition. Jackfruit being minor fruit crop no systematic research work has been carried out for improving the fruit set, yield and quality of jackfruit by foliar application of macro and microelements. Therefore, keeping these points in view the present experiment was carried out.

2. Material and Methods

A field experiment was conducted on ten-year-old jackfruit trees at Horticulture Research Centre Patharchatta, Department of Horticulture, GBPUAT, Pantnagar, and Uttarakhand, India. The experiment was laid out in Randomized Block Design to study the effect of foliar sprays of calcium and boron on fruit set, yield and quality of jackfruit. The experiment consisted of ten treatments viz. T_1: calcium carbonate 0.2%, T_2: calcium carbonate 0.4%, T_3: calcium carbonate 0.6%, T_4: borax 0.4%, T_5: borax 0.6%, T_6: borax 0.8%, T_7: calcium carbonate 0.2% + borax 0.4%, T_8: calcium carbonate 0.4% + borax 0.6%, T_9: calcium carbonate 0.6% + borax 0.8%, T_{10}: control. The mentioned combinations were sprayed three times *i.e.* first at the time of flower initiation, second one month after first spray and third two months after first spray. Observations on plant growth were recorded in terms of annual increase in height, canopy spread, stem girth, tree volume and cross-sectional trunk area. The plant height was measured with the help of measuring pole from the ground level to the highest crown level and expressed in meters (m). The tree trunks were marked 15 cm above ground level for recording stem girth. The stem diameter was measured with the help of vernier caliper at the marked point, the spread of each tree was measured in both the direction of East-West and North-South. The total number of fruits per tree was counted and data was expressed in percent fruit set, fruit length (cm) was measured from the apex to stem end of the fruit by vernier caliper, fruit width (cm) was measured at widest point of fruit by vernier caliper and mean values were presented. The weight of fruits was taken by electric balance and expressed in kilogram (kg). The fruit yield per tree was recorded by the total number of fruits on each tree multiplied by the average weight of fruits at the time of harvest and expressed in kilograms.

3. Results and Discussion

Plant Growth

The data presented in Table 1 revealed that foliar sprays of calcium and boron had a significant effect on plant growth. The maximum annual increase in plant height (0.57 m), maximum increase in canopy spread (0.67 m), maximum increase in stem girth (1.14 cm), higher increase in tree volume (0.135 m^3), maximum increase in cross sectional trunk area (0.104 cm^2), were noted with the treatment T_9 (calcium carbonate 0.6% + borax 0.8%) while, minimum values of these parameters were observed under control (T_{10}). The increase in vegetative growth in relation to plant height, canopy spread, stem girth, tree volume, cross sectional trunk area due to combined application of calcium and boron which may be attributed to their stimulatory effect on plant metabolism. Calcium plays a vital role in growth and development of the plant. In the leaves of plants, calcium is found mainly in the form of calcium pectate. Its function becomes vital in cell division, cell elongation, maintenance of the integrity of membrane, functioning and development of roots and has been concerned as a second messenger for various plant responses to both environmental and hormonal signals (Rashid, 2000; Ilyas *et al*., 2014). The Ca is directly involved in improving photosynthesis which results in high leaf number (Hussain *et al*., 2003). Boron is one of the important critical factors to plant growth, whereas boron has been found to involve in important processes in the plant such as cell differentiation, cell division, cell wall synthesis, lignification and cell wall structural integrity thereby keeps meristematic activity sugar transport, metabolism of several vital compounds and respiration. In addition, boron enhances necessary compounds for metabolic processes and building organs thereby vegetative growth. Boron plays an important function in mobility of calcium inside the plants and that can explain why joining calcium and boron together in treatments almost had a considerable positive effect of vegetative growth in assessment with other treatments (Mustafa *et al*., 2017). These findings are in consonance with Shukla (2011) and Meena *et al*. (2014) in aonla as well as Sutanu *et al*. (2017) in pomegranate.

Fruit Set and Percent Fruit Set

The data depicted in Table 2 revealed that the maximum number of fruit set per tree (10.33) was recorded in treatment T_9 (calcium carbonate 0.6% + borax 0.8%), while the minimum number of fruit sets (6.66) was recorded in treatment T_{10} (control). The maximum percent fruit set (93.93%) was noted in treatment T_9

(calcium carbonate 0.6% + borax 0.8%), while minimum percent fruit set (83.65%) was recorded in control (T_{10}). Increase in the number of fruit sets and percent fruit set might be due to the role of boron in enhancing the capacity of another to produce pollen, pollen tube growth, pollen viability, pollen germination, fertilization. Calcium improves the formation of lignin and cellulose. These are required for building structure of plants or preventing the abscission layer formation which resulted in reduced fruit drop (Nijjar, 1985). Due to this positive response, an increase in the number of fruit sets and percent fruit set were recorded. The findings are in confirmation with earlier reports of Shukla (2011) in anola, Sarrwy *et al*. (2012) in date palm and Bhat *et al*. (2020) in apple.

Fruit Length, Fruit Width and Average Fruit Weight

The maximum length of fruit (34.43 cm) was recorded in treatment T_9 (calcium carbonate 0.6% + borax 0.8%), while minimum fruit length was recorded 25.66 cm in T_{10} (control). The maximum length of fruit (22.20 cm) was recorded in treatment T_9 (calcium carbonate 0.6% + borax 0.8%), while minimum fruit width was recorded 15.26 cm in T_{10} (control). Larger size of fruits (fruit length and fruit width) obtained with the application of boron and calcium might be due to their involvement in cell expansion, cell division and increased volume of intercellular spaces in the mesocarpic cells. It could also be due to an increase in mobilization of photosynthates from other parts of the plant towards the developing fruits that are an extremely active metabolic sink (Singh *et al.*, 2001). These observations are also in agreement with the work of Shukla (2011) in aonla, Korkamaz and Askin (2015) in pomegranate, Nagwa *et al.* (2017) in peach and Mustafa *et al.* (2017) in fig.

The maximum fruit weight (5.96 kg) was recorded with treatment T_9 (calcium carbonate 0.6% + borax 0.8%), while minimum fruit weight (3.76 kg) was recorded in control (T_{10}). The increment in average fruit weight might be due to the mobilization of minerals and photoassimilates from other parts of the plant towards developing fruits and involvement in cell expansion and cell division which ultimately reflected into more weight of fruits in treated plants. Foliar feeding of boron increased the fruit weight finally by maintaining a higher level of auxins in various parts of the fruits which helped in increasing the fruit growth (Kaur, 2017).

Fruit Yield

The higher fruit yield of 60.20 kg/tree was recorded with treatment T_9 (calcium carbonate 0.6% + borax 0.8%), while minimum fruit yield of 25.20 kg/tree was

Table 1: Response of foliar application of calcium and boron on vegetative traits of Jackfruit

Treatments	*Annual Increase in plant height (m)*	*Annual Increase in canopy spread (m)*	*Annual Increase in stem girth (cm)*	*Annual increase in tree volume (m^3)*	*Annual increase in CSTA (cm^2)*
T_1 calcium carbonate 0.2%	0.46	0.57	1.05	0.080	0.088
T_2 calcium carbonate 0.4%	0.50	0.60	1.07	0.094	0.091
T_3 calcium carbonate 0.6%	0.46	0.59	1.08	0.085	0.093
T_4 borax 0.4%	0.49	0.59	1.06	0.085	0.089
T_5 borax 0.6%	0.51	0.64	1.07	0.110	0.091
T_6 borax 0.8%	0.52	0.62	1.08	0.108	0.093
T_7 $CaCO_3$ 0.2%+ borax 0.4%	0.52	0.62	1.10	0.103	0.096
T_8 $CaCO_3$ 0.4%+ borax 0.6%	0.56	0.66	1.12	0.125	0.100
T_9 $CaCO_3$ 0.6%+ borax 0.8%	0.57	0.67	1.14	0.135	0.104
T_{10} control	0.44	0.54	1.03	0.067	0.085
C.D.at 5%	0.04	0.04	0.05	0.080	0.009
SE(m)±	0.01	0.01	0.01	0.094	0.003

Table 2: Response of foliar application of calcium and boron on reproductive traits of Jackfruit

Treatments	*Number of fruit set per tree*	*Per cent fruit set*	*Fruit length (cm)*	*Fruit width (cm)*	*Average fruit weight (kg)*	*Yield kg per tree*
T_1 calcium carbonate 0.2%	7.00	84.25	29.53	17.96	3.88	27.18
T_2 calcium carbonate 0.4%	7.33	84.71	30.53	19.23	4.23	31.16
T_3 calcium carbonate 0.6%	7.66	85.46	29.66	19.00	4.53	34.60
T_4 borax 0.4%	7.33	84.86	31.86	19.33	4.36	33.25
T_5 borax 0.6%	7.66	85.17	29.16	19.30	4.89	39.14
T_6 borax 0.8%	8.33	89.25	32.83	19.43	5.35	44.66
T_7 $CaCO_3$ 0.2%+ borax 0.4%	8.66	92.96	29.33	19.36	5.22	48.56
T_8 $CaCO_3$ 0.4%+ borax 0.6%	9.33	92.96	33.76	21.00	5.73	52.97
T_9 $CaCO_3$ 0.6%+ borax 0.8%	10.33	93.93	34.43	22.20	5.96	60.20
T_{10} control	6.66	83.65	25.66	15.26	3.76	25.20
C.D.at 5%	1.27	5.95	4.86	2.75	0.61	7.07
SE(m)±	0.42	2.00	1.62	0.91	0.20	2.37

recorded in control (T_{10}). The increase in yield per tree might be due to the increase in the number of fruits per tree, the larger size of fruits and more fruit weight with the application of calcium and boron. The significant increase in yield by boron treatment might be due to the beneficial effect of boron on increasing the rates of carbohydrates and RNA metabolism (Parr and Loughman, 1983). These findings substantiate the earlier reports on this aspect by with Awasthi

and Lal (2009) in guava, Shukla (2011) in aonla, Sankar *et al*. (2013) in mango, Nagwa *et al*. (2017) in peach, Sutanu *et al*. (2017) in pomegranate, Ogiela *et al*. (2019) in pear and Bhat *et al*. (2020) in apple.

4. Conclusion

On the basis of above findings, it can be concluded that for obtaining higher plant growth, good fruit yield, jackfruit trees should be sprayed thrice with calcium carbonate 0.6%+ borax 0.8% at monthly intervals starting from initiation of flowering.

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