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Effect of pre harvest foliar application of micronutrients and sorbitol on flowering, pollen fertility and fruit set of litchi cv. Bombai

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Abstract
An investigation was carried out to study the effect of foliar spray of micronutrients, *viz*, calcium and boron and sorbitol on fruit-set, yield and fruit quality in litchi (*Litchi chinensis*). cv. Bombai, grown at Regional Research Station, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya. The experiment was laid out in Randomized Block Design (RBD), with three replications and seven treatments including control *viz.* T_1 – (Calcium nitrate – 0.06%), T_2 – (Boric Acid – 0.02%), T_3 – Sorbitol – 2%, T_4 - Calcium nitrate – 0.06% + Sorbitol – 2%, T_5 - Boric Acid – 0.02% + Sorbitol – 2%, T_6 - Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2%, and T_7- control plot. Results revealed that Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2%, were the most effective for enhancing initial fruit set (61.37) and number of fruit per panicle at harvest (32.00), yield (41.72 kg /tree), fruit weight (29.14 g), TSS (20.80 °Brix), total sugars (16.80%) and ascorbic acid content (23.80 mg / 100 g). while control recorded minimum yield, fruit weight, TSS and total sugar content of fruits.

Keywords: Fruit set, litchi, micronutrient, sorbitol, quality, yield

Introduction

Litchi fruit belongs to genus *Litchi* from soapberry family, sapindaceae is believed to have originated in China. It is highly specific to climatic requirements and probably due to this reason its cultivation is restricted to few countries in the world. Litchi contains good amount of fiber which increase metabolism fat, protein and carbohydrate. Fiber rich foods have proved to suppress appetite and increase metabolism.

Nutrient management is essential for maximum yield, good quality and profitability (Menzel and Simpson, 1987) [10]. Pre-harvest foliar application of various chemicals have been reported to enhance the shelf life of fruits by reducing physiological loss in weight and decay losses during storage of fruits. Foliar application of nutrients has become an important practice in the production of fruits. Foliar spray of nutrients is an important method for micronutrient application because plants can absorb the nutrients much quicker and smaller quantities may be required for normal growth as against the large quantities of the same may be required for soil application. At early stage of litchi growth there is initiation of cracking of pericarp. Fruit cracking is enhanced by hot dry winds, low relative humidity, high temperature, lack or excessive irrigation. Calcium is structural component of cell wall. In litchi fruit calcium participates in cracking resistance because trees having higher calcium levels shows lower cracking incidence while low exchangeable calcium in plants results in high cracking incidence (Li *et al.*, 2001) [9]. Thus, calcium related physiological disorders can be decreased by the foliar application of calcium on the fruit. Experiment in litchi showed that borax at 0.4% not only decreased the fruit cracking but also increased total soluble solids and total sugar contents of the fruits.

In the line of foregoing, it is necessary that to establish a method for improving pollination and fruit retention in mango. But the main problem lies in its nutrients deficiency particularly boron, calcium and carbohydrate. Foliar spray of nutrient are generally quick and 6-20 times more effective to the plant than soil application (Silbabush, 2002) [20]. The present experiment was conducted to evolve the combination of foliar spray of calcium, boron and sorbitol to overcome the nutrient deficiencies in order to enhance the pollen viability, fruit set, fruit retention and yield in litchi cv. Bombai.

Material and Methods

The experiment was conducted on 12 years old orchard at regional Research station Gayespur, BCKV during the year 2016- 2018. It comes under the New alluvial zone, (22^{0}95 north latitude and 88^{0}49 east longitude). These place receive average annual rainfall of 1300-1500 mm with average maximum and minimum temperature of 38 ^{0}C and 10 ^{0}C. The soil at the experimental field was Gangetic alluvial with sandy clay loam texture, good water holding capacity, well drained with moderate soil fertility status and soil pH of 6.9. Cultivars Bombai was taken for study. Experimental plot was laid out in RBD design having seven treatments including control with three replications. Seven treatments included T_1 – (Calcium nitrate – 0.06%), T_2 – (Boric Acid – 0.02%), T_3 – Sorbitol – 2%, T_4 - Calcium nitrate – 0.06% + Sorbitol – 2%, T_5 - Boric Acid – 0.02% + Sorbitol – 2%, T_6 - Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2%, and T_7- control plot. Spraying of all the micronutrient and sorbitol was done at 50% initiation of panicle. The observations were recorded on percent fruit-set, yield (kg/tree), fruit weight (g), total soluble solids (°Brix), acidity, ascorbic acid, and total sugars. The percentage of fruit retention was also calculated by taking the average of data obtained from the whole tree from each replication on the basis of formula;

Results and Discussion

Table 1: Effect of pre harvest foliar application of micronutrients and sorbitol on flowering, pollen fertility and fruit set of litchi cv. Bombai

Treatments	No of staminate flowers	Number of hermaphrodite flowers	Pollen fertility (%)	Initial fruit set	Number of fruit / panicle at harvest
T_1	857.10	269.00	81.72	49.25	24.00
T_2	894.12	271.00	84.79	53.00	27.00
T_3	891.42	273.00	86.32	58.00	30.00
T_4	890.72	291.20	87.11	51.00	28.00
T_5	894.72	298.00	87.33	53.48	28.50
T_6	888.34	302.00	89.79	61.37	32.00
T_7	831.00	261.00	76.20	33.10	13.00
C.D (P=0.05)	5.13	3.11	2.72	4.11	1.23
S.Em (±)	15.92	9.17	7.11	12.13	3.39

T_1 – Calcium nitrate – 0.06%, T_2 – Boric Acid – 0.02%, T_3 – Sorbitol – 2%, T_4 - Calcium nitrate – 0.06% + Sorbitol – 2%, T_5 - Boric Acid – 0.02% + Sorbitol – 2%, T_6 - Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2%, and T_7- control

Data presented in table -1 shoed that that application of micronutrients and sorbitol significantly increased number of staminate flowers. Number of staminate flowers are found maximum in treatment T_5 (Boric Acid – 0.02% + Sorbitol – 2%) which is at par with treatment T_2 (Boric Acid – 0.02%). Number of hermaphrodite flowers and pollen fertility are recorded highest with Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2% and lowest in control. Spray of Boron was attributed to stimulation of pollen germination, growth of pollen tube, stimulation of fertilization process and higher synthesis of metabolites (Perez Lopez and Reyes, 1983) [14] and also due to reduction in absicission of buds and flowers under the influence of boron (Rajput and Chand, 1975) [15]. Yehia and Hassan (2005) [27] also reported that borax and urea applications could be attributed to enhanced pollen germination and pollen tube growth which increased fruit set and yield. Present findings are conformity with the earlier works. It was also noted that Carbohydrate also plays an essential role in pollen tube growth. Deficiency in carbohydrate metabolism in the anther leads to abnormal pollen development in many plants (Bhadula and Sawtinev, 1989).

Data presented in Table 1 indicated that application of micronutrients and sorbitol significantly increased fruit-set. Initial fruit set and number of fruits/ panicle at harvest (61.37, 32.00) was recorded with Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2%, followed by boric acid 0.02% + sorbitol 2% (53.48, 28.50); and, the lowest (33.10,13.00) was observed in Control. Increase in fruit-set with application of boron and carbohydrates was also been observed by Stino *et al.* (2011) [25] and Singh *et al.* (2013) [22]. The application of boron reported to improve the fruit set in Le Conte pear (Badawi *et al.*, 1981) [1]. This might be due to boron associated with hormonal metabolism, photosynthate accumulation and water relation, thereby increasing retention of fruits. The results are in conformity with those reported by Mishra and Khan (1981); Sarkar *et al.* (1984) [18]; Brahmachari *et al.* (1997) [4] and Brahmachari and Kumar (1997) [4] in litchi.

Application of boron sprays is often used to measure the sufficient amounts of boron are available for flower fertilization, fruit set and early fruitlet development (Stover *et al.*, 1999 and Solar and Stampar, 2001) [26, 24]. Boric acid involved in various physiological processes and enzymatic activities. This might have contribution for better photosynthesis, greater accumulation of starch in fruits. The involvement of boron translocation of starch to fruit and auxin synthesis. The balance auxin in plant regulates the fruit drop or fruit retention in plants, which altered the control of fruit drop and increased the total number of fruits per tree. Similar results were observed by Kavitha (2000) [5] in papaya and Sarolia *et al.* (2007) in guava. The minimum number of fruits was recorded in control (Table 3).

Yehia and Hassan (2005) [27] reported that borax and urea applications could be attributed to enhanced pollen germination and pollen tube growth which increased fruit set and yield.

Carbohydrate also plays an essential role in pollen tube growth. Deficiency in carbohydrate metabolism in the anther leads to abnormal pollen development in many plants (Bhadula and Sawtinev, 1989). Sorbitol is a carbohydrate that can be transported in many plants (Taiz and Zieger, 1991).

Table 2: Physical characters of fruit as influenced by different pre harvest treatments

Treatments	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Yield (kg/ha)
T_1	25.97	4.97	3.11	37.50
T_2	26.72	5.11	3.41	37.91
T_3	26.18	5.12	3.71	37.61
T_4	27.11	4.99	3.69	37.92
T_5	27.32	5.14	3.91	38.11
T_6	29.14	5.91	3.94	41.72
T_7	25.32	4.92	3.10	36.12
C.D (P=0.05)	1.13	1.11	0.39	1.17
S.Em (±)	3.41	3.37	0.93	3.43

Fruit weight

It is evident from the table -2 that yield as number of fruits per tree was significantly increased by all treatments compared with the control. Plants sprayed with Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2% gave the highest fruit weight (29.14 g) while minimum in control (25.32 g). The average fruit weight was increased due to higher synthesis of metabolites, enhanced mobilization of photo assimilates and minerals from other parts of the plant towards developing fruits and source sink relationship takes place and involvement in cell division and cell expansion which ultimately reflected into more weight of fruit in treated plants. This finding is in confirmity with the findings of several workers in different fruit crops like, Mishra and Khan (1981) and Sarkar *et al.* (1984) [18] in litchi.

Fruit length and fruit breadth

It is clear that yield as number of fruits per tree was significantly increased by all treatments compared with the control. Maximum fruit length (5.91 cm) and breadth (3.94 cm) was observed in plant sprayed with Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2% and lowest in control. This might be due to boron increasing the fruit size due to increase in cell division and elongation process. Similar results were obtained by Rajput *et al.* (1976), Rath *et al.* (1980) [16] and Bhowmick *et al.* (2012) [3] in mango. This might due to role of borax in improving the internal physiology of developing fruit in terms of better supply of water nutrients and other compounds vital for their proper growth and development (Dutta and Banik, 2007). Beneficial role of boron in increasing the fruit length was also reported in mango cv. Dashehari (Singh *et al.*, 2003) [23].

Yield

It is observed from Table 2 that plants sprayed with Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2% recorded the highest yield (41.72 kg/tree), whereas Control recorded the lowest yield (36.12 kg/tree). Similar results were obtained by Negi *et al.* (2010) and Singh *et al.* (2013) [22]. Boron improves pollen grain germination and pollen-tube elongation, consequently leading to higher fruit-set and, finally, the yield (Abd-Allah, 2006). Further, it is evident from Table 2 that highest average fruit-weight (29.14 g) was recorded with Calcium nitrate – 0.06% + Boric Acid – 0.02% + Sorbitol – 2% which was at par with boric acid 0.02% + sorbitol 2% (27.32g); whereas, minimum average fruit weight (25.32 g) was recorded in Control. The present findings are collaborate with the findings of Korkmazl and Askın (2015) [8] who reported that the application of calcium nitrate 2% and boron 3% increased fruit set. This might be due to the greater stimulation of pollen germination and pollen tube growth by boron which acts with sugar to form a sugar borate complex (Ionizable) which moves through cellular membrane more readily than the non-borated, non-ionized sugar molecules and synthesis of pectin in the cell wall and addition to stimulatory effect due to oxygen uptake and sugar absorption. Similar finding were reported by Faust (1989) [6] and Bhowmick and Banik (2011) [2].

Table 3: fruits quality influenced by different pre harvest treatments

Treatments	TSS (ºbrix)	Acidity (%)	TSS:Acid ratio	Total sugar (%)	Ascorbic acid (mg/100g)
T_1	19.2	0.43	44.56	15.4	20.60
T_2	19.8	0.44	45.00	16.0	21.70
T_3	20.4	0.42	48.57	16.4	21.90
T_4	20.0	0.41	48.78	16.0	20.80
T_5	20.4	0.37	55.13	16.4	22.20
T_6	20.8	0.36	57.77	16.8	23.80
T_7	18.4	0.47	39.14	14.9	20.10
C.D (P=0.05)	0.37	0.06	-	1.01	1.06
S.Em (±)	0.93	0.18	-	3.10	1.19

Table 3 indicated that total soluble solids content in the fruit was significantly affected by various treatments with micronutrients and sorbitol. showed that maximum TSS was recorded with (20.80 °Brix), Calcium nitrate – 0.06% + boric acid 0.02% + sorbitol 2% and, the minimum TSS (18.40 °Brix) was recorded in Control. Increase in fruit TSS following borax application might be attributed to rapid mobilization of sugars and other soluble solids to developing fruits. These results are in conformity with the findings of Singh *et al.* (2004) [21] who noted that TSS was enhanced by application of boron in guava fruits. Increase in T.S.S. content with these micronutrients may be attributed to the quick metabolic transformations of polysaccharides and pectin into soluble compounds and rapid translocation from leaves to the developing fruits due to improved source- sink relationship.

These results are in close conformity with finding of Sanna and Abd El- Megeed (2005). Negi *et al.* (2009) [12] pointed out that increase in TSS by boron could be due to a more rapid translocation of sugars from the leaves to the developing fruits. Further, our treatment s significantly increased total sugars content in the fruit (Table 3).

Data presented in Table 3 indicate that acidity affected significantly by application of micronutrients or sorbitol. Data shows that the highest acidity (0.47%) was recorded in Control, and, the minimum (0.36%) with Calcium nitrate – 0.06% + boric acid 0.02% + sorbitol 2% which is at par with Boric Acid – 0.02% + Sorbitol – 2%. The lowest acidity by boron might be due to the role of boron in conversion of acid into sugar and their derivatives by the reaction involving reversal of glycolytic pathway. The results are also in conformity with Singh *et al.* (2012) who reported that minimum acidity (0.32%) was registered with the treatment of borax (1.0%) in mango cv. Dashehari. Similar results were also reported by Misra and Khan (1981) [11] and Pathak and Mitra (2008) [13] in litchi. Data reveals that maximum total sugars (16.80%) were recorded in plants treated with Calcium nitrate – 0.06% + boric acid 0.02% + sorbitol 2%, which was significantly higher than total sugars content in all the other treatments, including Control (14.90%). These findings are in conformity with findings of Banik *et al.* (1997) and Negi *et al.* (2009) [12]. Increase in total sugar content may be due to a breakdown of complex polymers into simple substances by hydrolytic enzymes. Boron facilitates sugar transport within a plant, and it is reported that borate reacts with sugars to form a sugar-borate complex that is more easily available to the transverse membrane (Gauch and Duggar, 1954) [7]. It is obvious from Table 3 that ascorbic acid content of the fruits significantly increased with application of micronutrients and sorbitol. Maximum ascorbic acid content (23.80 mg/100g pulp) was observed in fruits treated with Calcium nitrate – 0.06% + boric acid 0.02% + sorbitol 2%, followed by boric acid 0.02% + sorbitol 2% (22.20 mg/100g pulp), whereas, the minimum (20.10 mg/100g pulp) was recorded in Control. Similar findings were reported by Negi *et al.* (2009) [12] and Singh *et al.* (2013) [22]. Higher level of ascorbic acid with application of boron may be due to higher sugar content in the fruit as ascorbic acid is synthesized from sugars. TSS: acid ratio was found maximum with Calcium nitrate – 0.06% + boric acid 0.02% + sorbitol 2% and lowest in control.

Conclusion
It may be concluded from our studies, Calcium nitrate – 0.06% + boric acid 0.02% + sorbitol 2%, is the most effective treatment in improving fruit set, yield, fruit weight, TSS and total sugars. This recommendation can be forwarded in litchi cultivation.

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