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Influence of pre-harvest foliar application of micronutrients and sorbitol on pollination, fruit set, fruit drop and yield in mango (*Mangifera indica* L.) cv. ALPHONSO

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ABSTRACT : An experiment was carried out to study the influence of pre-harvest foliar application of calcium (0.06 %), boron(0.02%) and sorbitol (2 %) along with a control on pollination, fruit set, fruit drop, fruit growth parameters and yield of mango cv. ALPHONSO. The result revealed that maximum pollen viability (89.69%), germination (56.30%) and pollen tube growth (158.99µm), fruit set at pea stage (0.66%), fruit retension (2.23%),fruit length (9.98 cm), breadth (7.86 cm), weight (268.29 g), fruit volume (258.24 cc), number of fruit per tree (166.00) and yield per tree (44.60 kg)and minimum fruit drop (97.77%)were obtained under the foliar spray of boric acid (0.02%).

KEY WORDS : Mango, Pre-harvest spray, Micronutrient, Pollination, Fruit set, Yield

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Mango(*Mangiferaindica* L.) is one of the most luscious fruits of world, which occupies a prime position in the international fruit processing industry.Among the many constraints, fruit drop is a major problem in mango cultivation. In mango, in spite of profuse number of panicles and high initial fruit set, the ultimate retention and yield are low mainly due to heavy fruit drop (Bhowmick and Banik, 2011). The intensity of fruit drop is maximum within 15 days after pollination/anthesis in which about 60 per cent hermophorodite flowers and pea stage fruits are dropped. Second drop (about 30%) occurs between 28-35 days, when the fruits are at the marble stage. The third drop, which occurs irregularly from 40 days to maturity of fruits is quite low (3-5%) (Singh *et al*., 2009). Fruit drop and subsequent fruit retention is a serious problem in mango which drastically reduces the net return per unit area to the grower. Major causes attribute to this phenomenon are lack of pollination, low stigmatic receptivity, defective perfect flowers (having defective embryo sac development at anthesis), poor pollen transference, occurrence and extent of self incompatibility, competition between developing fruitlets and drought or lack of irrigation and incidence of pest and diseases (Swamy *et al*., 1988). The various factors attributed to malady include nutritional deficiency (lack of pollination and failure of fertilization, ovule abortion and embryo degeneration, low stigmatic receptivity and competition between developing fruitlets), assimilate limitation, hormonal imbalance and lack of irrigation and high or low relative humidity (Whiley, 1986 and Bains *et al.*, 1997).Adding to that boron deficiency resulted in low pollen viability, poor pollen germination, reduced pollen tube growth and low stigma receptivity (Nyomora and Brown, 1997).

Hence, high incidence of fruit drop at initial stages of fruit development has been a problem of serious concern in mango production. Boron and calcium have been found to induce pollen germination and fruit set in mango (Jutamanee *et al.*, 1998). Calcium spray increased the productivity of mango basically due to reduce abscission (Kumar *et al.*, 2006). 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).

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). 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 mango cv. ALPHONSO.

RESEARCH METHODS

The present experiment was carried out at department of Fruit Crops,Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu. The selected trees of mango cv. ALPHONSO were nine years old, planted at 10 m x 5m and irrigated by drip irrigation system. The experimental trees were managed with uniform cultural practices as per the standard recommendations with respect to manures and fertilizers, irrigation, plant protection measures etc. Fifty six healthy trees were selected nearly similar in vigour and size. The experiment was laid out in Randomized Block Design (RBD) with seven treatments replicated four times. The treatment were T_1- calcium nitrate - 0.06% (active ingredient 0.150 %), T_2- boric acid 0.02% (active ingredient 0.114%), T_3- sorbitol -2% (fine sorbitol), T_4- calcium nitrate 0.06% + boric acid 0.02%, T_5- calcium nitrate 0.06% + sorbitol -2%, T_6- boric acid 0.02% + sorbitol -2% and T_7- control (water spray). Time of application or spray was done at 50% flowering stage. For pollen studies, male and hermaphroditeflowers were collected 7 days after spraying. Pollen viability was tested with 1% acetocarmine stain and pollen grains which got stained were considered viable.

Pollen germination was determined by using cavity slide containing 20 ppm boric acid with 25 per cent sucrose solution. These were placed in Petri dishes over glass rods containing moist filter paper and water column covering about 2 mm of the dish-bottom. A moist filter paper was also fastened to the undersurface of the dish-cover. The rate of pollen tube elongation was measured at 4, 8, 12, 16, 20 and 24 hours of incubation at room temperature.Generally, the pollen grain was considered as germinated when the pollen tube length was atleast equal or greater than the diameter of the pollen itself. Pollen size, pollen viability, pollen germination and pollen tube growth were recorded under the microscope. At full bloom 20, panicles/tree distributed at the four directions were chosen at random and tagged. The following were determined; number of fruits set/panicle, number of fruits drop/panicle(15 days interval to still harvest), percentage of fruit retention at harvest time were calculated. Retained fruits were calculated by the following equation:

$$\textbf{Retained fruits (\%)} = \frac{\textbf{Retained fruit number at harvest}}{\textbf{Initial number fruit set}} \textbf{ x 100}$$

Fruit length and width of fruit were measured with the help of vernier in centimeters. Data on the number of fruits per tree and yield of fruit per tree have been recorded on the basis of weight of total fruit harvested and subjected to analysis of variance given by Panse and Sukhatme (1985).

RESEARCH FINDINGS AND DISCUSSION

The result obtained from the present investigation are summarized below:

Pollen viability and germination:

Although mango is a premier fruit of India, the development of mango orcharding in the form of a distinct industry is yet a distant goal (Singh, 1967). Many reasons have been attributed to the slow progress of this industry in India but next to the much-debated problem of periodicity of cropping, the problem is low fruit set and lower ultimate yield causing considerable distress to the growers (Sharma and Singh, 1970). The result revealed that pollen viability significantly different in each treatment. Spraying of boric acid (0.02%) (T_2) significantly increased the pollen viability(89.69%) followed by calcium nitrate spraying of 0.06% (86.65%) (T_1) compared to control (70.88%)(Table 1). This may be due to the influence of boron which increased the flavonoid content of pollen, carbohydrate absorption and translocation process, which indirectly affects the supply of nutrients during critical development stage (Parr and Laughman, 1983; Nyomora, 1995). The major role of boron in fruit trees involved fruit set. It is essential for reproduction, aids in the formation of pollen germination and pollen tube growth (Faust, 1989). 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).

The maximum pollen germination was started at 4 hours after inoculation of pollen in growing medium. Boric acid

0.02% (T_2) significantly recorded maximum mean pollen germination percentage (56.30%) and pollen tube growth (158.99 µm) followed by boric acid (0.02%) + sorbitol – (2%) (T_6) (Table 1).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) and Bhowmick and Banik (2011).

The perfect and normal pollen grain of all treatment were measured and average size between 27.41µ to 28.30 µ and their size ranges in microns are given in Table 1.

Fruit set, fruit drop and fruit retention:

The successful fruit set and retention of fruits till harvest are considered to improve the yield and yield attributes. The data clearly showed that all the chemical treatment increased the fruit setting per cent during pea stage. The maximum fruit set percentage was recorded in boric acid 0.02% (0.66%) followed by calcium nitrate 0.06%(0.58%). Lowest fruit set was observed with control (0.25%) (Table 2). This might be due to boron which increases the pollen producing capacity of the anther, pollen viability, pollen germination and pollen tube growth, thus finally leading to higher fruit set. Similar results were obtained by Qin (1996) in sweet orange and Hassan (2000) in olive. Perica *et al.* (2001) stated that application of boron prior to flowering increased fruit set of olive cv. MANZANILLO. Foiliar application of boron before full bloom or after harvest increased fruit set and fruit yield of pear cv. Conference (Wojcik and Wojcik, 2003).

Fruit drop is a serious problem of mango growers, which occur from the stage of fruit set till harvest. Heavy losses due to fruit drop are seen in the mango orchards resulting in reduction in the economic return (Maurya *et al*., 1973). Fruit drop was higher in initial stages of fruit growth. Which showed a decreasing trend with the advancement of maturity. Total fruit drop per panicle varied significantly among different treatments in 15 days after fruit set. In first 15 days after fruit set very high drop was noticed between 56.33 per cent in $T_2$and 75.05 per cent in T_7 and it become 84.04 per cent to 91.82 per cent within 30days after fruit set. Total fruit drop percentage per panicle was at 75 days after fruit set and it ranged between 97.77 per cent in T_2 and 99.09 per cent in control (Table 2).

Irrespective of treatment maximum rate of fruit drop was recorded within 30 days after fruit set. At the initial stage there is a numerous number of fruit per panicle which results a very high competition among the fruit lets for the nutrition and water requirement. At later stage the fruit number is greatly reduced which reduced the growth rate. As the result the rate of fruit drop is higher at initial stage and lower at later stage.

Fruit drop percentage was significantly affected by different treatments. Spraying boric acid at 0.02 per cent registered the lowest value of fruit drop (97.77%) and control treatment recorded highest value of fruit drop (99.09%). This could be due to the influence of boron on auxin balance which could have prevented fruit drop along with the involvement of fertilization and hormonal metabolism. This finding is in confirmation with the finding of Rani and Brahmachari (2001) in litchi.

The result indicated that control trees exhibited the lowest fruit retention per panicle at harvest stage. On the contrary, the trees treated with boric acid 0.02% per cent recorded the highest percentage of fruit retention (2.23%) at mature stage. Which was followed by calcium nitrate 0.06% (1.97%). The control plant recorded minimum percentage of fruit retention (0.91) (Table 2). 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); Brahmachari *et al.* (1997) and Brahmachari and

Table 1: Effect of calcium, boron and sorbitol on pollen size, pollen viability, pollen germination and pollen tube growth of mango cv. ALPHONSO under *in-vitro* condition

Treatments	Pollen size (µm)	Pollen viability (%)	Pollen germination (%)	Pollen tube growthlength at 4 hr intervals (µm)					
				4	8	12	16	20	24
T_1	27.97	86.65	49.26	45.33	90.84	131.67	133.60	135.03	137.51
T_2	28.30	89.69	56.30	49.51	108.57	151.01	153.79	155.48	158.99
T_3	27.50	73.69	45.60	40.74	91.35	131.54	133.24	134.13	137.21
T_4	27.94	79.04	48.90	43.61	86.98	125.62	128.57	131.02	132.53
T_5	27.78	73.76	42.09	39.12	80.12	119.62	122.64	123.24	125.98
T_6	28.21	83.81	52.76	45.84	97.41	140.01	140.44	141.02	144.14
T_7	27.41	70.88	38.85	36.22	72.78	111.85	115.40	116.31	118.65
S.E. $\pm$	0.953	1.228	1.482	1.3319	2.8416	2.667	2.747	2.968	3.083
C.D. (P=0.05)	NS	2.580	3.114	2.798	5.970	5.604	5.771	6.236	6.478

Kumar (1997) in litchi.

Fruit size and fruit weight:

Growth and development is an irreversible increase in size and weight of the fruit. It normally reflects an increase in protoplasm, which may occur through increase both in cell size and in the number of cells. Hence, the process of cell elongation and cell division provides the basis of fruit growth. The division and enlargement of cell is a complicated process involving synthesis of many organic compounds such as protein, cellulose and nucleic acid (Kumar, 1999). Application of boric acid 0.02% (T_2) recorded the maximum of fruit length (9.98 cm), breadth (7.86cm), fruit weight (268.29g) and fruit volume (258.24) and minimum in control plants (Table 3). The average fruit weight was increased due to higher synthesis of metabolities, 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 confirmation with the findings of several workers in different fruit crops *viz.,* Mishra and Khan (1981) and Sarkar *et al.* (1984) in litchi and Dutta and Dhua (2002) and Dutta (2004) in mango. Fruit length and fruit breadth were increased in the treatment of boric acid 0.02 per cent. 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) and Bhowmick *et al*. (2012) in mango. The increase in fruit volume is directly proportional to fruit weight. Fruit volume was highest in boric acid 0.114 per cent due to the favourable effect of boron when applied during the 50 per cent bloom stage enhancing the yield. The increased fruit volume might be due to their involvement of hormonal metabolism, increased cell division and expansion of cell (Rani and Brahmachari, 2001).

Number of fruits per tree:

It is clear that yield as number of fruits per tree was significantly increased by all treatments compared with the control. Foliar application of boric acid 0.02% significantly recorded the maximum number of fruit (166.00/tree) per tree. 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

Table 2 : Effect of calcium, boron and sorbitol on fruit set, fruit drop and fruit retention of mango cv. ALPHONSO

Treatments	Fruit set at pea stage (%)	Fruit drop percentage at 15 days intervals					Fruit retention (%)
		15	30	45	60	75	
T_1	0.58	61.35	85.39	90.57	95.07	98.02	1.97
T_2	0.66	56.33	84.04	88.70	94.58	97.77	2.23
T_3	0.34	69.57	88.91	94.92	96.39	98.80	1.20
T_4	0.38	66.50	87.67	94.41	95.88	98.46	1.53
T_5	0.31	71.07	90.16	94.94	96.75	98.83	1.16
T_6	0.51	64.88	87.21	92.80	95.42	98.38	1.61
T_7	0.25	75.05	91.82	95.96	97.25	99.09	0.91
S.E.±	0.0070	0.651	0.510	0.480	0.151	0.118	0.118
C.D. (P=0.05)	0.0148	1.369	1.071	1.010	0.316	0.248	0.248

Table 3: Effect of calcium, boron and sorbitol on fruit physical characteristics and yield of mango cv. ALPHONSO

Treatments	No. of fruits /tree	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Fruit volume (cc)	Yield per tree (kg)
T_1	154.12	9.79	7.71	256.98	246.92	39.6
T_2	166.00	9.98	7.86	268.29	258.24	44.6
T_3	106.25	9.29	7.41	240.84	234.44	25.53
T_4	122.00	9.52	7.58	246.23	239.4	30.03
T_5	100.12	9.21	7.31	238.49	229.69	23.89
T_6	143.12	9.64	7.66	250.14	242.63	35.78
T_7	73.50	8.57	7.16	232.18	225.31	17.06
S.E.±	5.10	0.069	0.021	1.791	1.524	1.512
C.D. (P=0.05)	10.71	0.145	0.045	3.764	3.203	3.177

per tree. Similar results were observed by Kavitha (2000) in papaya and Sarolia *et al*. (2007) in guava. The minimum number of fruits was recorded in control (Table 3).

Increased fruit set due to 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) and also due to reduction in absicission of buds and flowers under the influence of boron (Rajput and Chand, 1975).

Yield (kg/ tree):

Yield per tree is the culmination of the interplay of several factors *viz.*, biometrical, physiological characters and yield parameters. The purpose of all cultural operations adopted is to manipulate many factors, thereby to attain increased yield (Bose and Mitra, 2002). An increase in number of fruits without any depressing effect on fruit size can be claimed as increased yield per plant. The more number of fruit per tree (166.00/tree) and maximum yield (44.60 kg/tree) were obtained from the trees treated with spraying of boric acid (0.02%) followed by calcium nitrate (0.06%), control plant produced lowest number of fruit per tree (73.50) and yield (17.06 kg/tree) (Table 3). The significant increase in fruit yield (kg/tree) is a cumulative effect of increase in number of fruits because of reduction in fruit drop *vis-à-vis* higher fruit weight by the direct and indirect effect of foliar spray of boron and calcium. These were promotion of starch formation followed by rapid transportation of carbohydrates in plant. This might be due to increased fruit set and retention. Increased fruit set due to 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) and also due to the reduction in abscission of buds and flowers under the influence of boron (Rajput and Chand, 1975).

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