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

C. SANKAR, D. SARALADEVI and S. PARTHIBAN

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 retention (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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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 × 5 m 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 hermaphroditic flowers 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 at least 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:

\[
\text{Retained fruits (\%)} = \frac{\text{Retained fruit number at harvest}}{\text{Initial number fruit set}} \times 100
\]

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%) (\( T_{1} \)) significantly increased the pollen
viability (89.69%) followed by calcium nitrate spraying of
0.06% (86.65%) (\( T_{2} \)) 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.) 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.) (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. Foliar 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 T₁ and 75.05 per cent in T₂ and it become 84.04 per cent to 91.82 per cent within 30 days 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 T₂ 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, photosynatate 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   | Pollen viability | Pollen germination | Pollen tube growthlength at 4 hr intervals (µm) |                      |
|                 | (µm)          | (%)            | (%)              | 4                      | 8                    | 12                     | 16                     | 20                     | 24                     |
| T₁              | 27.97        | 86.65         | 49.26          | 45.33                  | 90.84                | 131.67                | 133.60                | 135.03                | 137.51                |
| T₂              | 28.30        | 89.69         | 56.30          | 49.51                  | 108.57               | 151.01                | 153.79                | 155.48                | 158.99                |
| T₃              | 27.50        | 73.69         | 45.60          | 40.74                  | 91.35                | 131.54                | 133.24                | 134.13                | 137.21                |
| T₄              | 27.94        | 79.04         | 48.90          | 43.61                  | 86.98                | 125.62                | 128.57                | 131.02                | 132.53                |
| T₅              | 27.78        | 73.76         | 42.09          | 39.12                  | 80.12                | 119.62                | 122.64                | 123.24                | 125.98                |
| T₆              | 28.21        | 83.81         | 52.76          | 45.84                  | 97.41                | 140.04                | 140.44                | 141.02                | 144.14                |
| T₇              | 27.41        | 70.88         | 38.85          | 36.22                  | 72.78                | 111.85                | 115.40                | 116.31                | 118.65                |
| S.E. ±          | 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% (T2) recorded the maximum of fruit length (9.98 cm), breadth (7.86 cm), fruit weight (268.29 g) and fruit volume (258.24) and minimum in control plants (Table 3). 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 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.

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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit set at pea stage (%)</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>Fruit retention (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.58</td>
<td>61.35</td>
<td>85.39</td>
<td>90.57</td>
<td>95.07</td>
<td>98.02</td>
<td>1.97</td>
</tr>
<tr>
<td>T2</td>
<td>0.66</td>
<td>56.33</td>
<td>84.04</td>
<td>88.70</td>
<td>94.58</td>
<td>97.77</td>
<td>2.23</td>
</tr>
<tr>
<td>T3</td>
<td>0.34</td>
<td>69.57</td>
<td>88.91</td>
<td>94.92</td>
<td>96.39</td>
<td>98.80</td>
<td>1.20</td>
</tr>
<tr>
<td>T4</td>
<td>0.38</td>
<td>66.50</td>
<td>87.67</td>
<td>94.41</td>
<td>95.88</td>
<td>98.46</td>
<td>1.53</td>
</tr>
<tr>
<td>T5</td>
<td>0.31</td>
<td>71.07</td>
<td>90.16</td>
<td>94.94</td>
<td>96.75</td>
<td>98.83</td>
<td>1.16</td>
</tr>
<tr>
<td>T6</td>
<td>0.51</td>
<td>64.88</td>
<td>87.21</td>
<td>92.80</td>
<td>95.42</td>
<td>98.38</td>
<td>1.61</td>
</tr>
<tr>
<td>T7</td>
<td>0.25</td>
<td>75.05</td>
<td>91.82</td>
<td>95.96</td>
<td>97.25</td>
<td>99.09</td>
<td>0.91</td>
</tr>
<tr>
<td>S.E.</td>
<td>0.0070</td>
<td>0.651</td>
<td>0.510</td>
<td>0.480</td>
<td>0.151</td>
<td>0.118</td>
<td>0.118</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>0.0148</td>
<td>1.369</td>
<td>1.071</td>
<td>1.010</td>
<td>0.316</td>
<td>0.248</td>
<td>0.248</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of fruits/tree</th>
<th>Fruit length (cm)</th>
<th>Fruit breadth (cm)</th>
<th>Fruit weight (g)</th>
<th>Fruit volume (cc)</th>
<th>Yield per tree (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>154.12</td>
<td>9.79</td>
<td>7.71</td>
<td>256.98</td>
<td>246.92</td>
<td>39.6</td>
</tr>
<tr>
<td>T2</td>
<td>166.00</td>
<td>9.98</td>
<td>7.86</td>
<td>268.29</td>
<td>258.24</td>
<td>44.6</td>
</tr>
<tr>
<td>T3</td>
<td>106.25</td>
<td>9.29</td>
<td>7.41</td>
<td>240.84</td>
<td>234.44</td>
<td>25.53</td>
</tr>
<tr>
<td>T4</td>
<td>122.00</td>
<td>9.52</td>
<td>7.58</td>
<td>246.23</td>
<td>239.4</td>
<td>30.03</td>
</tr>
<tr>
<td>T5</td>
<td>100.12</td>
<td>9.21</td>
<td>7.31</td>
<td>238.49</td>
<td>229.69</td>
<td>23.89</td>
</tr>
<tr>
<td>T6</td>
<td>143.12</td>
<td>9.64</td>
<td>7.66</td>
<td>250.14</td>
<td>242.63</td>
<td>35.78</td>
</tr>
<tr>
<td>T7</td>
<td>73.50</td>
<td>8.57</td>
<td>7.16</td>
<td>232.18</td>
<td>225.31</td>
<td>17.06</td>
</tr>
<tr>
<td>S.E.</td>
<td>5.10</td>
<td>0.069</td>
<td>0.021</td>
<td>1.791</td>
<td>1.524</td>
<td>1.512</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>10.71</td>
<td>0.145</td>
<td>0.045</td>
<td>3.764</td>
<td>3.203</td>
<td>3.177</td>
</tr>
</tbody>
</table>
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 abscission 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 Mitrta, 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 fruits due to foliar 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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