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Effect of foliar application of micronutrients and sorbitol on fruit quality and leaf nutrient status of mango cv. ALPHONSO

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ABSTRACT : An experiment was conducted at Horticultural College and Research Institute, Periyakulam (Tamil Nadu) on effect of foliar application of micronutrients and sorbitol on the fruit quality and nutrient content in leaf of mango cv. Alphonso and found that the lower concentration of B, Ca and sorbitol had influenced in fruit quality compared to control. The treatment boric acid 0.02 per cent significantly increased the TSS, total sugars (%), reducing sugar (%), non-reducing sugar (%), ascorbic acid (mg/100g), carotenoids (mg/100g), sugar acid ratio and lowest values of acidity. In case of nutrient status in mango leaves N, P, K and B content were found to be higher in boric acid 0.02 per cent, while calcium content was maximum in calcium nitrate 0.06 per cent spray.

KEY WORDS : Mango, Micronutrient, Sorbitol, Quality, Leaf nutrient

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Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae and originating in South East Asia, is the most cultivated and favourite fruits of the tropical region (Purseglove, 1972). Mangoes considered as the king of fruits in plenty of the countries worldwide. It is the premier and choice fruit of India and undoubtedly is one of the best fruits, owing to its delicious taste, excellent flavour and pleasant fragrance. Amongst various varieties grown in India, Alphonso is considered as the choicest variety owing to it's wide adoptability and excellent fruit quality (Badhe *et al.,* 2007). It is excellent source of vitamin A (6375 – 20750 / µg/100g β carotene) and Vitamin C (6.8 – 38.8 mg/100g) and mineral contents (Chandra and Chandra, 1997). Quality production, market value and export of mango suffer from several limiting factors including nutritional deficiency. Among the different nutrients, boron has major role in declining fruit quality in mango (Raja *et al.,* 2005). Alphonso is the only variety, which is mostly exported to the countries like UK, UAE, Kuwait, Saudi Arabia, Baharin, Qutar, Bangaladesh, most of middle East and Gulf countries.The quality of mango is judged on the base of size, TSS, acidity, total sugars, ascorbic acid and sugar acid ratio, β-carotene and attractive golden yellow colour on ripening

In India, some physiological stress and quality related issues has been raised in mango orchard. It was observed that unbalanced fertilization, micronutrient deficiency, poor tree management and inadequate cultural practices are mainly responsible for orchard related quality issues. According to horticulturists, only application of primary nutrients could not prove successful to produce high quality fruit in mango trees, the application of micronutrients is compulsory as well. Foliar spray of micronutrients is the common practice to overcome the micronutrients deficiencies in order to improve the fruit quality. Rath *et al.* (1980) applied zinc or boron each at the rate of 0.2-0.8 per cent on 13 years old mango cv. Langra trees at full bloom stage and found the tremendous enhancement in total sugars, TSS and ascorbic acid of fruit at higher rates of boron or zinc. Singh and Dhillon (1987) found significant strengthening in TSS and total sugars of mango fruits due to application of different concentration of boric acid to mango trees. Micronutrients are key elements in plant growth, development and quality of fruits. The Ca and B are essentially required and play very important role in assiminate, various enzymatic activities and synthesis. These micronutrients also help in uptake of major nutrients and play an active role in the plant metabolic processes (Das, 2003). With this above background, the present study was conducted to assess the influence of foliar application of boron, calcium, sorbitol in improving the fruit quality and leaf nutrient status in mango.

RESEARCH METHODS

The trail was carried out at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu. Trees were nine years old, planted at 10 x 5 m spacing, grown under the same common agricultural practices. Fifty six healthy trees were selected nearly similar in vigor and size. This experiment aimed to study the effect of some chemicals on fruit quality and leaf nutrient content of Alphonso mango cultivar. The experimented was initiated at 50 per cent bloom stage with 'the following treatments of foliar application 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). The treatments were arranged in a Randomized Complete Block Design with three replicates for each treatment and two trees per each replicate.

Sample of five mature fruits per tree were randomly taken and kept in laboratory till ripe stage. The chemical composition of alphonso fruit was determined by using standard procedures. Total soluble solids were determined with hand reflractometer. Total sugars, reducing sugar, acidity was noted by titration against 0.1 N NaOH using phenolphthalein as indicator. Ascorbic acid was measured by titration against 2, 6-dichlorophenolindo phenol were estimated by the method described in A.O.A.C (1975). The leaf sampling procedure as described by Koo and Young (1972) was followed. Fully matured (6-7 month old) healthy leaves were collected from middle of the shoot in each treatment at fifteen days after spraying and five days before harvest from fruiting shoots. Tissues concentration of nitrogen was determined by Kjeldhal's methods's, phosphorus by vanadomolybdate method (Jackson, 1973) and potassium by flame photometer (Chapman and Pratt, 1961). The content of boron was estimated by Caramine method (Hatchar and Wilcox, 1950) and calcium was estimated using Versenate method (Cheng and Bray, 1951). The attained data were tabulated and statistically analyzed according to Panse and Sukhatme (1967). The mean values were compared by LSD at 5% level of probability.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Quality parameters:

Table 1 showed the effect of different treatments on biochemical properties of fruits. Total soluble solids (TSS) determine the quality and consumer preference. The TSS content was increases in the fruits as ripening advances. Total soluble solids content was significantly different among the treatments. The data presented in Table 1 indicated that the TSS (21.81 ^{0}Brix) was maximum recorded in spraying of boric acid 0.02 per cent (T_2) followed by calcium nitrate 0.06 per cent (T_1) (20.57 ^{0}Brix). The lowest TSS content was registered by the control treatment (T_7) (18.31 ^{0}Brix).

Table 1 : Effect of foliar application of calcium, boron and sorbitol on the fruit quality of mango cv. Alphonso

Treatments	Total soluble solids (^{o}Brix)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Titrable acidity (%)	Ascorbic acid content (mg/100 g)	Carotenoids (mg/100 g)	TSS / acid Ratio
T_1	20.57	14.87	4.75	10.12	0.309	38.40	11.20	66.43
T_2	21.81	15.55	4.85	10.70	0.283	40.42	12.34	73.63
T_3	19.71	13.74	4.78	9.27	0.345	36.18	11.47	57.13
T_4	19.96	14.03	4.59	9.51	0.336	33.54	10.48	59.33
T_5	19.15	13.93	4.40	9.55	0.357	32.12	11.32	53.60
T_6	20.21	14.59	4.69	9.91	0.322	35.10	11.64	62.65
T_7	18.31	13.32	4.29	9.04	0.394	31.21	9.66	46.41
S.E.±	0.0518	0.047	0.0270	0.066	0.002	0.220	0.0397	0.890
C.D. (P=0.05)	0.1089	0.099	0.056	0.140	0.004	0.462	0.083	1.870

The increased TSS content due to fact that boron is known to increase transportation of sugar and forms complexes with sugar. This confirms with the findings of Khanduja *et al.* (1976) and Chharia (1977) in grapes, Sarkar *et al.* (1984); Jain *et al.* (1985) in litchi, Banik *et al.* (1997), Meena *et al.* (2006) and Nehete *et al.* (2011) in mango.

The data presented in Table 1 indicated that the maximum total sugar (15.55%), reducing sugar (4.85%) and non-reducing sugar (10.70%) were obtained from the trees treated with boric acid 0.02 per cent (T_2). The increase in sugar and different fraction of sugars might be due to boron probably augmented the conversion of starch to sugar and it has also been opined that boron increases transportation of sugars, hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites and rapid translocation of photosynthates and minerals from other parts of the plant to developing fruits. This findings is in agreement with those of Rajput and Chand (1975), Yamdagni *et al.* (1979) in grapes and Pandey *et al.* (1988) in guava.

During ripening there was a fall in acidity. The foliar application of boric acid 0.02 per cent (T_2) significantly recorded the minimum transformed titrable acidity percentage (0.283) compared to control. This might be due to their utilization in respiration and rapid metabolic transformation of organic acids into sugars. This observation is in corroboration with the finding of Mishra and Khan (1981) in litchi. 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. Similar findings were reported by Sarkar *et al.* (1984) in litchi, Hoggag *et al.* (1995), Banik *et al.* (1997) in mango and Meena *et al.* (2005) in grapes.

During ripening ascorbic acid in general progressively decreases with an increase in the storage period on account of oxidation of ascorbic acid (Badhe *et al.*, 2007). The higher value of ascorbic acid (40.42mg/100g) content observed in the treatment T_2 receiving 0.02 per cent boric acid, might be due to higher level of sugars in boron treated fruit, which increased the content of ascorbic acid, since ascorbic acid is synthesized from sugar. Similar result was observed by Brahmachari *et al.* (1997) in litchi and Rawat *et al.* (2010) in guava.

Boric acid spray of 0.02 per cent significantly increased the carotenoids content (12.34 mg/100g) compared to control (9.66 mg/100 g of fruit). This might be due to boron which enhanced the ripening of fruits. The tremendous increase on ripening could be attributed to their accelerated biosynthesis during ripening process as reported by Badhe *et al.* (2007) in mango.

Transformation of organic acids to sugars is one of the reasons for decrease in acidity during fruit maturity and ripening (Badhe *et al.*, 2007). Fruit quality is mainly judged by the balance between total sugar and acidity present in the fruit. Therefore, TSS: acid ratio plays an important role in determing the quality of the fruit (Gayon, 1968). Beside the higher TSS per acid ratio (73.63) was recorded in T_2 compared to control. This might be due to accumulation and translocation of sugars that increased the TSS and acidity was on lower side in the fruit. Similar results were obtained by Sharma *et al.* (2005) in litchi.

Nutrient status of mango leaf:

The healthy as well as matured leaves of mango were used for analysis of nutrient status in the present study. The leaf analysis was done at two times *i.e.* fifteen days after spray and five days before first harvest. The foliar application of boric acid, calcium nitrate and sorbitol and their combination on mango were found to have pronounced result with respect to their nutrient status during experiment. Nutrient management in broader sense aims at making available all the nutrients at optimum quantities demanded by the plant. The nutrients *viz.*, nitrogen, phosphorus, potassium, calcium and boron play a major role in plant growth and development and ultimately increasing the productivity and quality of fruits.

Result in Table 2 showed that nitrogen content is the leaves were significantly affected by all the treatment except control. The nitrogen content of leaves significantly varied

Table 2 : Effect of foliar application of calcium, boron and sorbitol on the nutrient content in leaf of mango cv. Alphonso

Treatments	Nitrogen (%)		Phosphorous (%)		Potassium (%)		Calcium (ppm)		Boron (ppm)	
	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage
T_1	1.774	1.553	0.119	0.094	0.791	0.580	1.695	1.899	56.11	48.32
T_2	1.785	1.567	0.122	0.102	0.820	0.593	1.677	1.887	98.52	84.60
T_3	1.745	1.523	0.109	0.082	0.762	0.558	1.643	1.861	42.23	34.04
T_4	1.763	1.534	0.116	0.091	0.774	0.570	1.685	1.892	75.40	59.43
T_5	1.717	1.514	0.102	0.077	0.756	0.563	1.670	1.874	51.84	44.11
T_6	1.765	1.547	0.116	0.087	0.781	0.575	1.653	1.886	81.78	78.26
T_7	1.683	1.505	0.094	0.075	0.734	0.545	1.634	1.854	34.09	28.50
S.E.±	0.0039	0.0026	0.0012	0.0011	0.0032	0.0016	0.0036	0.0024	2.0361	1.6915
C.D. (P=0.05)	0.0082	0.0054	0.0026	0.0024	0.0067	0.0034	0.0077	0.0054	4.2777	3.5537

from flowering to harvest. Gradual decrease in available nitrogen was recorded during flowering and harvest stages. Nitrogen is the primary nutrient, which has been mostly utilized by plants. Among the different treatments, the treatment T_2 receiving 0.02 per cent boric acid recorded the highest nitrogen content in leaves at flowering (1.785 %) and harvest stage (1.567%). This might be due to the fact that boron application induced a higher stimulation effect on leaf nitrogen (Pandey and Sinha, 2006). The leaf nitrogen was increased by boron application might be the result of intensified nitrate uptake from soil and decreased activity of nitrate reductase (Kumar and Purohit, 2001).

Phosphorus content in the leaves was significantly affected by all treatments compared to control. The highest phosphorus content in leaf tissues at flowering (0.122 %) and harvest stage (0.102 %) was recorded in the treatment T_2 receiving boric acid 0.02 per cent. This might be due to phosphorus uptake by leaves, phosphorus metabolism and translocation to plant. Similar finding was reported by Abd-Allah (2006) in sweet orange.

Data presented in Table 2 showed that there were significant differences among the treatments on potassium percentage in the leaves. The spay of boric acid 0.02 per cent increased potassium per cent in leaves at flowering (0.820 %) and harvesting stage (0.593 %) and lowest values was recorded in control. This might be due to the role of boron in encouragement of potassium absorption from soil rather than utilization in plant tissues (Sanna Ebeed and Abd El-Migeed, 2005).

It is obvious from Table 2 that calcium content in the leaves was significantly affected by treatments especially when trees sprayed with calcium nitrate 0.06 per cent (1.695%) and (1.899 %) and lowest was observed in control during flowering and harvest stage, respectively. Because of foliar applied calcium which was further absorbed by leaf and utilized for the physiological activity. This might probably be the reason for increased leaf calcium content. A similar result was obtained by Topcuoglu (2002).

The higher values of boron in the leaves at flowering (98.52 ppm) and harvesting stage (84.60 ppm) were obtained when trees sprayed with boric acid 0.02 per cent followed by boric acid + sorbitol (2%) while the lowest value was recorded with control. This might be due to presence of boron binding compounds in the cell which might have increased the mechanism of boron uptake, which is thought to be a non-metabolic process determined in plant by the formation of non-exchangeable boron complexes within the cytoplasm and cell wall. Similar finding was reported by Brown and Hu (1994); Saran and Kumar (2011) and Asgharzade *et al*. (2012).

In addition to the mineral elements supplied by xylem, high amounts of most elements reach the developing fruits from leaves through phloem (Norton and Wittwer, 1963 and Oland, 1963). Leaves being a donor organ for mineral elements to fruits, also supply carbohydrates to them for development (Pathak and Pandey, 1978).

The Table 3 indicated that, higher nitrogen content in shoots during flowering (1.565 %) and harvest stages (1.548 %) were recorded in the treatment T_2 of boric acid spray of 0.02 per cent. This might be due to the enhanced nitrogen uptake and utilization of nitrogen in cell physiology. Similar results was obtained by Pandey and Sinha (2006).

The gradual decrease in carbohydrate content of shoots was recorded during flowering and harvest stages. Among the different treatments, the treatment T_2 receiving 0.02 per cent boric acid recorded the highest carbohydrate content at flowering (27.61g/100g) and harvest stage (14.45g/100g) in shoots. The highest carbohydrate content in shoots might be due to the fact that boron enhanced the photosynthetic process which resulted in enhanced the accumulation of carbohydrate in the flowering shoots. Similar result was obtained by Nartvaranant *et al.* (1999) in mango. Boron is involved in carbohydrate transport within the plant. Boron ion may be associated with the cell membrane where it makes a complex with sugar molecules and facilitate its passage across the membranes (Gauch and Dugger, 1953).

Generally it is an accepted fact that shoots with higher starch, total carbohydrate content and C:N ratio favour flower

Table 3 : Effect of calcium, boron and sorbitol on shoot nitrogen, carbohydrates and C/N ratio content (%) of mango cv. Alphonso

Treatments	Shoot nitrogen content at different stages (%)		Shoot carbohydrate content at different stages (%)		Shoot C:N ratio at different stages	
	Flowering	Harvest	Flowering	Harvest	Flowering	Harvest
T_1	1.545	1.531	24.07	12.38	15.58	8.33
T_2	1.565	1.548	27.61	14.45	17.64	9.34
T_3	1.527	1.503	21.40	11.60	14.24	7.72
T_4	1.545	1.499	24.98	13.43	16.16	8.95
T_5	1.536	1.483	22.67	11.16	14.76	7.52
T_6	1.557	1.523	25.35	12.65	16.29	8.30
T_7	1.502	1.466	19.70	10.32	12.92	7.03
S.E.±	0.0032	0.0043	0.0473	0.3705	0.0465	0.2407
C.D. (P=0.05)	0.0067	0.0090	0.0993	0.7784	0.0977	0.5058

initiation in mango (Sen, 1973). Nitrogen, carbohydrate and C:N ratio of shoots are known to have significant influence on flower bud initiation and flowering in mango. Higher starch reserve, total carbohydrate content and C:N ratio in the shoots favour flower initiation and fruit set in mango (Mallik, 1953; Singh, 1960; Sen, 1973; Nartvaranant *et al*., 1999). In the present study, C:N ratio was recorded higher in shoot during flowering (17.64) and decline in harvest stage (9.34) in the treatment T_2 receiving 0.114 per cent boric acid (containing B 0.02 %). Boron involvement in inhibiting the auxin oxidation and enhancing auxin activity was reported by Parr and Loughman (1983). The transportation of cytokinin to the shoots which combined with auxin start to produce flowers if the trees have higher C:N ratio. However, the increment in the carbohydrate was greater than the nitrogen content, accordingly the C:N ratio considerably increased throughout the period. This result is in accordance with the findings of Sen (1973) in mango.

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