



Effect of foliar nutrition on yield, quality and shelf-life of mango (*Mangifera indica*) cv. Dashehari under Jammu sub-tropics

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ABSTRACT

The present investigation on effect of foliar nutrition on yield, quality and shelf-life of mango (*Mangifera indica* L.) was carried out on 20 years old mango trees cv. Dashehari having uniform vigour. The maximum fruit length (10.45cm), breadth (6.17cm), weight (170.17g) and highest fruit yield (99.72 kg/tree) of mango cv. Dashehari was recorded with the application of 2.0% Ca (NO₃)₂ + 2.0% KNO₃ + 1.0% ZnSO₄ + 0.02% H₃BO₃ (T₁₄). The maximum leaf N (1.25%), P (0.16 %) and K (0.29 %) and soil N (230.79 kg/ha), P (14.75 kg/ha), K (139.09 kg/ha), Ca (6.25 kg/ha), Mg (2.76 meq/100g), Zn (0.97 ppm) and B (0.28 ppm) were recorded with the foliar application of 2.0% Ca(NO₃)₂ + 2.0% KNO₃ + 1.0% ZnSO₄ + 0.02% H₃BO₃ (T₁₄). The findings indicated that the yield and nutrient status of mango cv. Dashehari can be improved with foliar application of 2.0% Ca (NO₃)₂ + 2.0% KNO₃ + 1.0% ZnSO₄ + 0.02% H₃BO₃ at pea stage.

Key words: Foliar, *Mangifera indica*, Mango, Micronutrients, Quality, Yield

Mango (*Mangifera indica* L.) is the most popular and the choicest fruit produced in the tropical and sub-tropical regions of the world. India is the largest producer of mango in the world contributing about 50% of total production worldwide (Barman *et al.* 2015). It is the most important fruit of India and has been in cultivation in Indian sub-continent over 4 000 years. In Jammu and Kashmir mango is grown in sub-tropical areas of Jammu, Samba, Kathua, Udhampur, Reasi and Rajouri districts of Jammu province. In Jammu sub-tropics from the last few years, some physiological stresses and quality related issues have been raised in mango orchards.

It was observed that unbalanced fertilization, micronutrient deficiencies, poor tree management and inadequate cultural practices are mainly responsible for orchard related issues and only the application of primary nutrients could not prove successful to produce high quality fruit in mango trees. This indicates that the application of micronutrients is compulsory as well. Various disorders have

been reported in mango emanating either due to deficiency or excess of micronutrients. 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. Foliar spray of micronutrients is generally quick, more effective and is a common practice to overcome the micronutrient deficiencies in order to improve the fruit quality (Silverbush 2002). The farmers usually apply nitrogen, phosphorous, potassium to orchard and hardly pay any attention to the micronutrients needed by the fruit trees. However, the major elements/micronutrients are quickly taken up and utilized by the tissues of the plants by the catalyzing effect of macronutrients/minor elements (Singh *et al.* 2009). Thus for increasing the efficiency and enhancing the quality and yield of fruit and mitigating the nutrition related problems, the foliar application of nutrients needs to be investigated. Therefore, keeping in view the low quality and productivity of mango, an experiment was conducted to study the effect of foliar nutrition on yield, quality, shelf-life, soil and leaf nutrient status of mango cv. Dashehari.

MATERIALS AND METHODS

The present experiment was carried out at the Experimental Research Orchard, Division of Fruit Science, FOA, Udheywalla, SKUAST-Jammu during the year 2014-15 on 20 years old mango trees cv. Dashehari having uniform vigour and size. The experimental site is located in the sub-tropical zone at 32.73° N and longitude of 74.87°

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E at an elevation of 327 m from the mean sea level with annual precipitation of about 1 200 mm. The foliar nutrient application was given in the morning hours at pea stage. Different treatment combination were T₁ (Ca(NO₃)₂ 2.0 %), T₂ (KNO₃ 2.0 %), T₃ (ZnSO₄ 1.0 %), T₄ (H₃BO₃ 0.02 %), T₅ (Ca(NO₃)₂ 2.0 % + KNO₃ 2.0 %), T₆ (Ca(NO₃)₂ 2.0 % + ZnSO₄ 1.0 %), T₇ (Ca(NO₃)₂ 2.0 % + H₃BO₃ 0.02 %), T₈ (KNO₃ 2.0 % + ZnSO₄ 1.0 %), T₉ (KNO₃ 2.0 % + H₃BO₃ 0.02 %), T₁₀ (ZnSO₄ 1.0 % + H₃BO₃ 0.02 %), T₁₁ (Ca(NO₃)₂ 2.0 % + KNO₃ 2.0 % + ZnSO₄ 1.0 %), T₁₂ (Ca(NO₃)₂ 2.0 % + KNO₃ 2.0 % + H₃BO₃ 0.02 %), T₁₃ (Ca(NO₃)₂ 2.0 % + ZnSO₄ 1.0 % + H₃BO₃ 0.02 %), T₁₄ (Ca(NO₃)₂ 2.0 % + KNO₃ 2.0 % + ZnSO₄ 1.0 % + H₃BO₃ 0.02 %), T₁₅ (KNO₃ 2.0 % + ZnSO₄ 1.0 % + H₃BO₃ 0.02 %) and T₁₆ (Spray with water only). Mechanical analysis of orchard soil for sand (%), silt (%) and clay (%) was done as per method suggested by Piper (1950). Chemical analysis of the soil samples was done to estimate pH, available Ca, Mg, EC (Jackson 1973), organic carbon (Walkley and Black 1934), available nitrogen (Subbiah and Asija 1956), available phosphorus (Olsen *et al.* 1954), available potassium (Merwin and Peech 1951), available zinc (Lindsay and Norvell 1978) and available boron (Berger 1994).

Leaf samples were collected in the month of March for recording initial nutrient status and sample was prepared as per method given by Chapman (1964). Total nitrogen (%) was estimated using Micro-Kjeldahl's method (Jackson 1973), total phosphorus (%) by vanadomolybdophosphoric acid yellow colour method (Jackson 1973), total potassium (%) by Flame photometric method, total calcium (%) and magnesium (%) EDTA-titration method (Prasad 1998), total zinc (ppm) DTPA method (Lindsay and Norvell 1978) and total boron (ppm) dry ashing method (Singh *et al.* 1999). Per cent fruit set at pea stage was recorded on the selected and tagged panicles by using following formula: Fruit set (%) = No. of fruits per panicle at pea stage/ No. of flowers × 100. Per cent fruit drop at 15th, 30th, 45th and 60th days interval after pea stage was calculated using formula, Fruit drop (%) = No. of fruits/panicle at pea stage - No. of fruits per panicle at different intervals after pea stage / No. of fruits/panicle at pea stage × 100. Total soluble solids, total sugars, reducing sugars and titratable acidity were analyzed according to standard procedure as given in AOAC (1995). Ascorbic acid was calculated by the method given by Ruck (1969). Organoleptic rating was done following Hedonic scale (1-9) points. For recording yield, total number of fruits harvested in each replication were counted and weighed on electronic balance, recorded as yield (kg/tree). The per cent loss in weight was worked out on 2nd, 4th, 6th, 8th, 10th and 12th day after harvest using formula initial weight- final weight/initial weight × 100 as suggested by Srivastava and Tandon (1968). Final soil and leaf nutrient status analysis was done using methods as mentioned above for analysis of initial nutrient estimation.

The experiment was laid in RBD with three replications having one tree per replication. Data generated during the course of study were subjected to statistical analysis as

prescribed by Panse and Sukhatme (2000).

RESULTS AND DISCUSSION

Data presented in Table 1 showed that different treatments had a significant effect on per cent fruit set and number of fruits/panicle where, maximum fruit set at pea stage (0.97%) and number of fruits/panicle (1.97) was observed in treatment T₁₄. It was further observed that the maximum fruit length (10.45 cm) and breadth (6.17 cm) was recorded under T₁₄ which might be due to the combined benefit of foliar application of different nutrient application (potassium, calcium, zinc and boron). It was also due to the fact that potassium plays a role to transfer of photosynthates to the fruits, whereas boron application improves cell division and cell elongation. The results are in accordance with Bhowmick *et al.* (2012) and Sankar *et al.* (2013) in mango. It was further observed that yield was significantly affected by different treatments where maximum yield per tree (99.72 kg/tree) and fruit weight (170.17 g) was recorded under treatment T₁₄. It was observed that boron involved in hormonal metabolism which helps to increase the cell division and cell elongation whereas, calcium play very important role in enzymatic activities and helps in uptake of major nutrients, zinc is associated with protein synthesis, carbohydrate metabolism, tryptophan synthesis and also act as catalyst in oxidation reduction process, its sprays seem to have benefitted all those activities which resulted in more

Table 1 Effect of foliar nutrition on per cent fruit set, number of fruits per panicle and physical characteristics of mango cv. Dashehari

Treatment	Per cent fruit set (at pea stage)	No. of fruits/ panicle	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield (kg tree)
T1	0.96	1.50	9.12	5.05	141.12	85.00
T2	0.97	1.52	9.61	5.41	146.05	87.64
T3	0.93	1.44	9.28	5.17	144.00	85.78
T4	0.94	1.55	9.55	5.37	145.73	86.99
T5	0.94	1.62	10.03	5.63	150.65	89.52
T6	0.89	1.47	9.94	5.55	147.80	88.00
T7	0.95	1.67	10.00	5.61	150.58	88.93
T8	0.90	1.52	10.16	5.81	159.60	91.45
T9	0.90	1.59	10.22	5.93	161.37	93.20
T10	0.91	1.60	10.10	5.75	154.00	90.79
T11	0.89	1.62	10.26	6.01	166.20	95.43
T12	0.91	1.70	10.36	6.08	166.32	97.10
T13	0.91	1.70	10.25	5.93	164.35	94.13
T14	0.97	1.97	10.45	6.17	170.17	99.72
T15	0.91	1.70	10.40	6.10	167.44	98.29
T16	0.92	1.42	9.01	5.00	140.48	84.00
CD (P=0.05)	N.S	N.S	0.18	0.11	3.55	3.91

photosynthates being available for fruit development. All these contributed to increased fruit weight and yield per tree. These findings are in alignment with the findings of Bhatt *et al.* (2008) and Singh *et al.* (2013) in mango.

Data in Table 2 showed that maximum pulp weight (109.75 g), and minimum stone weight (26.15 g) was recorded in fruits harvested from trees under T₁₄. The increase in the pulp weight might be attributed to the increased fruit size and weight which enhanced the mobility of sugars and minerals in expanded cell and intercellular space and translocation of photosynthates because of the combined application of the nutrients. The data indicated that the peel weight of mango was observed maximum (34.38 g) in fruits harvested from trees under treatment T₁₂. The increase in the peel weight might be attributed to the presence of calcium which is important in the formation of cell membrane and cell wall development and also due to increase in size and volume owing to the beneficial effect of combined application of calcium, potassium, zinc and boron. These findings are in conformity with the results of Bhowmick *et al.* (2012) who reported that the foliar application of zinc sulphate on mango at pea and marble stage resulted in maximum peel weight of mango fruit.

The perusal of the data in Table 2 indicated that highest TSS (21.29 °Brix) minimum acidity (0.22%) was recorded in fruits harvested under treatment T₁₄. It was observed that the influence of nutrients on physiological processes such as respiration and photosynthesis, which enhanced the supply of dry matter, minerals and carbohydrates towards the developing fruits. These results are in agreement with the findings of Razek *et al.* (2013) who reported that the pre-harvest foliar spray containing K, Zn besides other

elements was very effective in increasing TSS of mango fruit.

Data presented in Table 3 revealed that the maximum total sugars (15.07%), reducing sugars (3.98%), non-reducing sugars (10.53%) and ascorbic acid (41.82 mg/100g) pulp were recorded in fruits harvested from trees in T₁₄. The increased sugar contents might be due to the presence of potassium and boron which plays a very important role in the translocation of sugars from other parts into developing fruits. Similar findings were also observed by Sarker and Rahim (2013) who reported that total sugars and reducing sugars of mango fruit are significantly influenced by the foliar nutrition of mango trees with the foliar application of potassium. The increased contents of ascorbic acid in fruits might be due to combined effect of nutrients which activated the synthesis of ascorbic acid somewhere between D-glucose to L-ascorbate.

The results presented in Table 4 and Table 5 revealed that the soil and leaf N, P, K, Ca, Mg, Zn and B were significantly influenced by the foliar fertilization. Maximum soil N (230.79 kg/ha), P (14.75 kg/ha), K (139.09 kg/ha), Ca (6.25 kg/ha), Mg (2.76 meq/100g), Zn (0.97 ppm), B (0.28 ppm) and maximum leaf N (1.25%), P (0.16%), K (0.29%), Ca (1.79%), Mg (0.19%), Zn (14.67 ppm) and B (19.05 ppm) were recorded with the foliar fertilization of 2.0% Ca(NO₃)₂ + 2.0% KNO₃ + 1.0% ZnSO₄ + 0.02% H₃BO₃ (T₁₄). The increased level of soil and leaf nutrient status was due to the combined effect of applied nutrients and the present findings are in agreement with the findings of Sankar *et al.* (2013) who observed that the foliar application of boric acid and calcium nitrate on mango cv. Alphonso significantly influenced the status of N, P, K, Ca and B in leaves after fruit harvest with the highest values of N, P, K

Table 2 Effect of foliar nutrition on pulp weight, stone weight, peel weight and pulp/stone ratio of mango cv. Dashehari

Treatment	Pulp weight (g)	Stone weight (g)	Peel weight (g)	Pulp/stone ratio	TSS (°Brix)	Acidity (%)	TSS/acid ratio
T1	88.04	30.81	22.27	2.86	18.31	0.27	67.81
T2	90.99	29.51	25.55	3.08	18.52	0.26	71.23
T3	88.52	30.64	24.84	2.89	18.47	0.27	68.41
T4	90.50	30.62	24.61	2.96	19.08	0.26	73.38
T5	96.27	27.78	29.95	3.47	19.38	0.25	77.52
T6	91.67	29.45	26.68	3.11	19.15	0.25	76.60
T7	96.24	28.57	25.77	3.37	19.80	0.24	82.50
T8	101.46	26.94	31.20	3.77	19.42	0.25	77.68
T9	102.60	26.78	31.99	3.83	20.19	0.24	84.13
T10	98.78	26.96	24.91	3.66	20.15	0.24	83.96
T11	105.51	26.43	34.26	3.99	20.26	0.24	84.42
T12	105.66	26.28	34.38	4.02	20.41	0.23	88.74
T13	103.67	26.76	33.92	3.87	20.39	0.23	88.65
T14	109.75	26.15	34.27	4.20	21.29	0.22	96.77
T15	107.52	26.19	33.73	4.11	20.48	0.23	89.04
T16	87.01	31.93	21.54	2.73	18.30	0.28	65.36
CD (P=0.05)	1.25	1.22	0.24	N.S	0.67	0.06	N S

and B recorded with boric acid (0.02%), whereas highest Ca was recorded with calcium nitrate (0.06%). The results are also in line with the results of Taha *et al.* (2014) who reported that potassium application on mango trees increased

the status of N, P and K in leaves after harvest similarly, Hasani *et al.* (2012) in pomegranate observed that potassium application significantly increased Zn contents in leaves.

The results obtained in Fig 1, depicts that minimum per cent fruit drop (45.58, 73.16, 77.15 and 83.04% at 15, 30, 45 and 60 days intervals, respectively) was recorded with the foliar application of 2.0% $\text{Ca}(\text{NO}_3)_2$ + 2.0% KNO_3 + 1.0% ZnSO_4 + 0.02% H_3BO_3 . The decrease in per cent fruit drop might be primarily due to the involvement of boron in hormonal metabolism, photosynthesis and water retention in the plants, thereby resulting in prevention of fruit drop. Moreover, spraying of potassium had a positive effect on reducing fruit drop as it might be due to increase in carbohydrate and protein synthesis by potassium that has the ability of activating complex enzyme systems in the plants which catalyze metabolic reactions related to carbohydrate and protein synthesis and also because potassium and zinc increases tolerance to several biotic and abiotic stresses. These findings are in conformity with the findings of Sankar *et al.* (2013) in mango where they reported that pre-harvest application of boric acid (0.02%) recorded minimum per cent fruit drop in mango similarly, Vashistha *et al.* (2010) also observed that spraying mango trees at pea stage with mixture of zinc sulphate (0.4%), borax (0.4%) and urea (1.0%) recorded minimum per cent fruit drop.

The per cent physiological weight loss was found minimum 4.83, 8.07, 11.01, 16.61, 24.51 and 29.63 % at 3, 4, 6, 8, 10 and 12 days, respectively, after storage under ambient conditions in the fruits harvested from trees receiving T_{14} . The reduction in weight loss might be primarily due to the role of calcium in the formation of cell membrane,

Table 3 Effect of foliar nutrition on total sugars, reducing sugars and non-reducing sugars of mango cv. Dashehari

Treatment	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100g pulp)
T1	12.99	3.18	9.32	37.52
T2	13.72	3.54	9.67	38.22
T3	13.70	3.45	9.74	38.16
T4	13.76	3.61	9.64	38.20
T5	13.82	3.67	9.64	39.34
T6	13.78	3.65	9.62	38.34
T7	13.98	3.72	9.75	39.24
T8	13.95	3.71	9.73	39.51
T9	14.08	3.81	9.76	39.52
T10	14.04	3.79	9.74	39.50
T11	14.15	3.82	9.81	39.55
T12	14.44	3.88	10.03	39.59
T13	14.23	3.85	9.86	39.52
T14	15.07	3.98	10.53	41.82
T15	14.55	3.91	10.11	40.74
T16	12.43	2.95	9.01	35.59
CD (P=0.05)	0.26	0.14	0.27	2.15

Table 4 Effect of foliar nutrition on leaf N, P, K, Ca, Mg, Zn and B of mango cv. Dashehari

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (ppm)	B (ppm)
T ₁	1.12 (6.07)	0.09 (1.72)	0.23 (2.73)	1.73 (7.56)	0.14 (2.14)	10.00	14.34
T ₂	1.14 (6.13)	0.10 (1.84)	0.25 (2.86)	1.71 (7.50)	0.15 (2.19)	10.00	14.00
T ₃	1.11 (6.05)	0.08 (1.65)	0.23 (2.73)	1.71 (7.50)	0.14 (2.17)	11.00	13.84
T ₄	1.12 (6.07)	0.09 (1.68)	0.22 (2.71)	1.72 (7.53)	0.15 (2.22)	10.33	15.06
T ₅	1.16 (6.19)	0.10 (1.84)	0.24 (2.83)	1.74 (7.57)	0.16 (2.29)	10.67	14.43
T ₆	1.15 (6.15)	0.09 (1.68)	0.23 (2.75)	1.73 (7.56)	0.15 (2.24)	11.67	14.85
T ₇	1.14 (6.13)	0.10 (1.84)	0.23 (2.75)	1.74 (7.57)	0.15 (2.24)	10.67	15.66
T ₈	1.17 (6.22)	0.09 (1.68)	0.24 (2.82)	1.71 (7.52)	0.16 (2.31)	12.00	14.34
T ₉	1.13 (6.10)	0.10 (1.84)	0.25 (2.86)	1.72 (7.53)	0.16 (2.29)	10.33	16.02
T ₁₀	1.15 (6.15)	0.09 (1.71)	0.24 (2.81)	1.72 (7.53)	0.15 (2.24)	12.00	15.35
T ₁₁	1.18 (6.23)	0.12 (1.98)	0.28 (3.05)	1.74 (7.57)	0.15 (2.24)	11.67	15.14
T ₁₂	1.16 (6.19)	0.13 (2.06)	0.26 (2.94)	1.78 (7.66)	0.16 (2.29)	11.33	16.03
T ₁₃	1.17 (6.22)	0.12 (2.01)	0.24 (2.81)	1.76 (7.61)	0.18 (2.41)	12.33	15.59
T ₁₄	1.25 (6.41)	0.16 (2.27)	0.29 (3.09)	1.79 (7.69)	0.19 (2.52)	14.67	19.05
T ₁₅	1.15 (6.16)	0.12 (1.98)	0.26 (2.90)	1.74 (7.57)	0.17 (2.36)	13.33	15.33
T ₁₆	1.10 (6.03)	0.08 (1.64)	0.22 (2.71)	1.71 (7.50)	0.14 (2.17)	9.67	13.64
CD (P=0.05)	0.07	0.03	0.03	0.03	0.02	2.08	1.09

Figures given in parenthesis are transformed (angular) values.

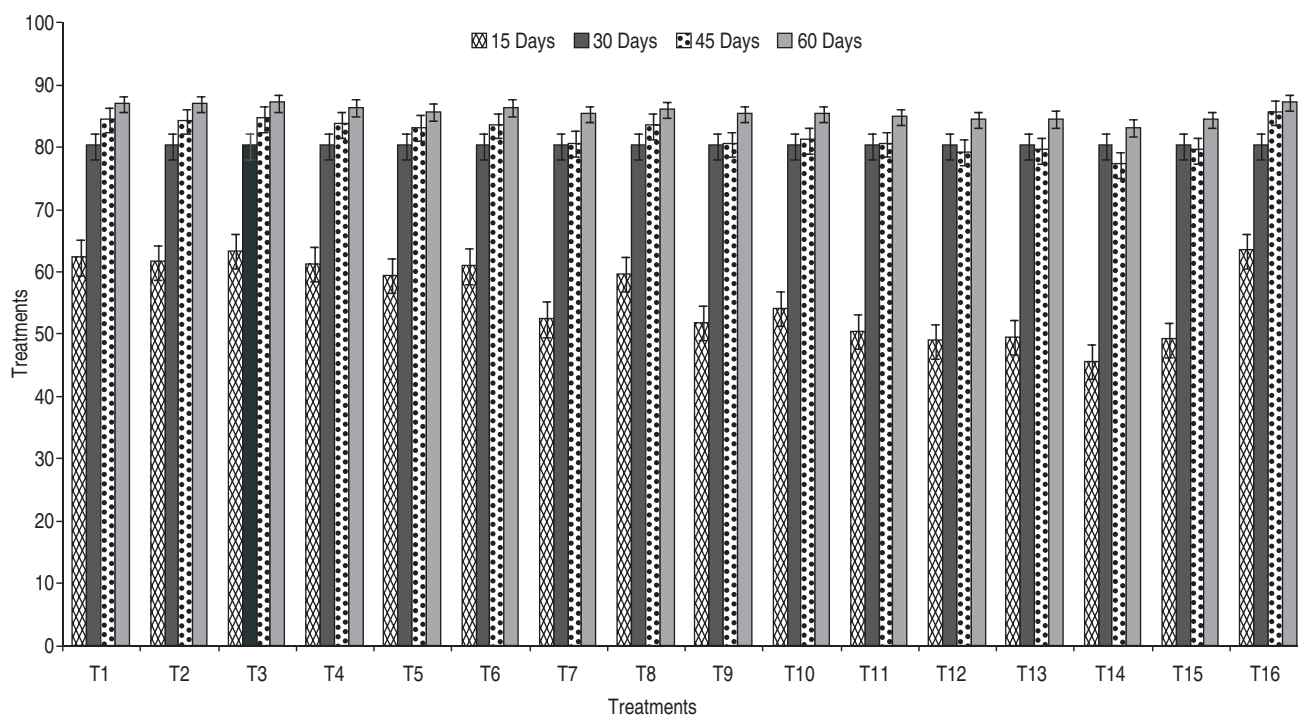


Fig 1 Effect of foliar nutrition on per cent fruit drop of mango cv. Dashehari at 15 days interval after fruit set

Table 5 Effect of foliar nutrition on soil N, P, K, Ca, Mg, Zn and B of mango cv. Dashehari

Treatment	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (meq/100 g)	Zn (ppm)	B (ppm)
T1	224.31	14.28	138.20	6.12	2.66	0.88	0.19
T2	225.04	14.31	138.35	6.08	2.64	0.90	0.21
T3	223.80	14.16	138.19	6.10	2.63	0.91	0.18
T4	222.90	14.39	138.32	6.07	2.66	0.89	0.23
T5	224.25	14.14	138.61	6.15	2.67	0.89	0.20
T6	222.58	14.30	138.27	6.13	2.68	0.91	0.22
T7	224.80	14.38	138.55	6.17	2.67	0.88	0.23
T8	223.66	14.08	138.64	6.08	2.69	0.92	0.22
T9	223.37	14.19	138.78	6.03	2.70	0.89	0.23
T10	226.43	14.68	138.67	6.07	2.64	0.92	0.23
T11	225.04	14.38	138.68	6.19	2.70	0.91	0.22
T12	226.40	14.57	138.72	6.21	2.69	0.89	0.23
T13	228.15	14.21	138.67	6.18	2.68	0.93	0.24
T14	230.79	14.75	139.09	6.25	2.76	0.97	0.28
T15	227.13	14.58	138.91	6.15	2.72	0.92	0.23
T16	222.52	13.91	138.08	6.06	2.66	0.90	0.19
CD (P=0.05)	3.92	0.16	0.15	0.06	0.05	0.04	0.04

maintenance of fruit firmness, retardation of respiratory rates as well as transpiration. Moreover, potassium has a role in hardening of tissues or stabilisation of their membranes which may have reduced the evapo-transpiration losses from fruits. Zinc favours accumulation of calcium in fruit tissues whereas; boron application enhances production of better quality fruits. The present findings are in conformity with Karemera and Habimana (2014) who reported that

the pre-harvest calcium sprays on mango trees resulted in extending the shelf-life of mango fruit after harvest. Based on the experimental results obtained, it was concluded that the yield, quality and shelf-life of mango cv. Dashehari can be increased with foliar application of 2.0% calcium nitrate+2.0% potassium nitrate+1.0% zinc sulphate+0.02% boric acid at pea stage which also increased soil and leaf nutrient status of mango.

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