Effect of Pre-harvest Application of Ca, K, B and Zn on Yield and Quality of Mango (Mangifera indica L.) cv. Langra

Anugya Kumari*, Rewati Raman Singh and Manoj Kundu

Department of Fruit and Fruit Technology, Bihar Agricultural University, Sabour-813210, Bhagalpur, Bihar, India

*Corresponding author

A B S T R A C T

The present study was conducted to investigate the role of calcium, potassium, boron and zinc on yield and quality of mango cv. Langra. The treatments include CaCl₂ 4%, CaCl₂ 6%, CaCl₂ 8%, K₂SO₄ 1.0%, K₂SO₄ 1.5%, K₂SO₄ 2.0%, Borax 1.0%, Borax 1.5%, Borax 2.0%, ZnSO₄ 0.2%, ZnSO₄ 0.4%, ZnSO₄ 0.8%) and T₁₃ control. Spraying was done 30 days before anticipated day of harvesting. The result revealed that among all the treatments borax 2% was most effective in increasing fruit weight, pulp weight, and pulp percentage. Whereas CaCl₂ 4.0% had given highest yield/plant with better fruit quality attributes. On the other hand number of fruits per plant and fruit quality parameters such as TSS, TSS: acid ratio, sugars, total carotenoids, ascorbic acid content, total phenolics was highest in borax 1%. Thus, present study concluded that borax 1% and CaCl₂ 4% was most efficient in enhancing yield and yield attributes as well as in retaining the quality of mango fruits.

Keywords: Mango, Potassium, Calcium, Boron, Zinc, Yield, Quality

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Introduction

Mango (Mangifera indica L.) is choicest fruit crop of India, cultivated in tropical and subtropical region around the world. India is leading producer and around 2.516 MT/ha area is under mango cultivation with an annual production of 18431 MT. Although, production of this crop is very high but the productivity is quite lower than other fruit crops (Anonymous, 2015). Mango fruits are esteemed due its pleasing aroma, marvellous flavour, luscious taste, attractive colour with high nutritive value, which has fascinated the market.

Among the various cultivars of northern India, Langrais one of the main cultivar which is widely cultivated and preferred by the consumers. Although it is one of the choicest
variety but its yield is very low. This main reason for lower yield is its biennial bearing habit, low fruit set, excessive fruit drop, poor fruit growth, development of abscission layer and deficiency of nutrients in different part of the country.

Application of different macro and micronutrients has shown immense potential to increase the yield and productivity of mango with improved fruit quality (Selvaraj et al., 2000). Potassium plays major role in many biochemical and physiological processes such as growth, yield, quality and biotic and abiotic tolerance (Cakmak, 2005; Pettigrew, 2008). The potassium treatments improve the productivity of several mango cultivars (Baiea et al., 2015; Taha et al., 2014). On the other hand, calcium spraying increased the productivity of mango due to the reduction of abscission layer formation (Kumar et al., 2006). Calcium application safely supplements endogenous calcium to fresh fruits during development of fruits (Raese and Drake, 2000). Boron improves translocation of sugar, cell wall synthesis and their structure as well as lignifications that affect fruit quality (Blevins and Lukaszewski, 1998). Zinc plays an important role in enzymatic reactions and helps in better growth and development. It also regulates the metabolism of protein as well as carbohydrate and improves the auxin content which helps in fruit retention.

Various experiments have been conducted on foliar spray of micro-nutrients, shown significant response to improve yield and quality of fruits and found 10 to 20 times more efficient than soil application (Shukla, 2011; Zaman and Schumann, 2006).

Present study was planned to evaluate the response of foliar spray of calcium, potassium, boron and zinc on yield and quality of mango fruits cv. Langra.

**Materials and Methods**

**Experimental site**

The research was done in mango orchard of Bihar Agricultural College, Sabour, Bhagalpur.

**Plant materials and treatments**

For this study 21 years old mango trees (Mangifera indica L.) cv. Langra of uniform vigour, growing in a compact block were selected. All the trees were managed under similar cultural schedule during whole period of study. Randomized block design (RBD) with 13 treatments and 3 replications for each, were used for this experiment.

The details of experimental treatment plan employed in this study are as follow: T1 (CaCl2 4%), T2 (CaCl2 6%), T3 (CaCl2 8%), T4 (K2SO4 1.0%), T5 (K2SO4 1.5%), T6 (K2SO4 2.0%), T7 (Borax 1.0%), T8 (Borax 1.5%), T9 (Borax 2.0%), T10 (ZnSO4 0.2%), T11 (ZnSO4 0.4%), T12 (ZnSO4 0.8%) and T13 Control (Water spray). These nutrients were applied as foliar spray at 30 days before harvest of fruits.

**Observation recorded**

**Yield attributing characters and yield**

Total numbers of fruits for each replication under each treatment were counted manually. Fruit weight, Pulp weight, peel and stone weight, yield per plant as well as Yield per ha were recorded. Fruit length and width was measured by using Vernier calliper (mm). Specific gravity and fruit volume was calculated by conventional water displacement method. Pulp: stone ratio was calculated by dividing weight of pulp with weight of stone and also edible: non-edible ratio was estimated.
Fruit quality attributes

Total soluble solids were recorded with the help of hand refractometer. Titratable acidity was calculated by standard titration method (AOAC, 2000). TSS: TA ratio was calculated by dividing the TSS with titratable acidity. Total sugar was done by using Lane and Eynone (1923) method and expressed in percentage. Total carotenoids was evaluated by the protocol of Roy (1973) and values were expressed as mg 100 g⁻¹ fresh weight basis (FW). Ascorbic acid was estimated by 2, 6-dichlorophenol indophenol dye method (Jones and Hughes, 1983) and results were expressed in mg 100/g FW. Total phenols were extracted by a method described by Singleton et al., (1999) and were expressed as microgram of gallic acid equivalent/100 g FW (mg GAE g⁻¹FW). Total Antioxidant activity was calculated according to the protocol of Apak et al., (2004) CUPRAC assay and expressed as μmol Trolox equivalent/100 gFW.

Statistical analysis

The Data were analyzed using statistical analysis software SAS 9.2 and means were calculated by using Duncan’s multiple range test. Mean difference were tested by ‘F’ test at five per cent level of significance. Treatments were compared at five per cent level of significance.

Results and Discussion

Yield attributing characters

Fruit weight, number of fruits per plant, yield per plant and yield per ha

Total number of fruits from each plant, fruit weight, yield/plant and yield/ha were presented in table-1. Result revealed that all the treatments have significantly higher number of fruits per plant. Borax1% (191.33) had maximum number of fruits per plant followed by borax 1.5% (184.33) while minimum (140.00) in untreated plant. Fruit weight was highest in borax 2.0% (353.07 gm) followed by CaCl₂ 4% (351.83) and minimum in K₂SO₄ 1.5% (275.73 gm). Foliar application of boron showed positive effect because it promotes cell division, expansion, sugar metabolism and accumulation of carbohydrates (Sourour, 2000). It also helps in better photosynthesis, accumulation of starch and auxin synthesis. The balance auxin in plant regulates the fruit drop and helps in maximum number of fruit retention. Similar results were reported in mango, papaya and guava (Sankar et al., 2013; Kavitha, 2000; Sarolia et al., 2007). The appreciable improvement in fruit weight by boron application had been reported by Pathak et al., 2011, Bhatt et al., 2012; Bhowmick et al., 2012; Singh et al., 2012; Yadav et al., 2013. It might be due to involvement of boron in hormonal metabolism, cell division and expansion and also enhanced assimilates accumulation from other parts to developing fruits. However, the maximum yield/plant and yield/ha (63.79 kg, 6.37 t/ha respectively) was recorded in CaCl₂ 4.0% while the minimum in control. Boron and calcium significantly increased yield, it might be an increase in fruit number as fruit drop reduced, higher fruit weight. These results were in agreement with earlier studies of Singh and Maurya, 2004 and Singh et al., 2012 in mango.

Fruit weight, fruit length, width, volume and specific gravity

Table 2 showed that treatments have significant effects on fruit weight, length width and volume. The maximum fruit length and volume was recorded in CaCl₂ 4.0%. Appreciable improvement in fruit length and volume by CaCl₂ application might be because of hormonal metabolism, increased cell
division and expansion, synthesis and changes of carbohydrates and carbohydrate enzyme (Rani and Brahmachari, 2001; Banis et al., 1997). The similar reports were found by Kulkarni and Yewale (2012) and Karemera and Habimana (2014). The maximum fruit width (80.81 mm) was recorded in ZnSO₄ 0.8% while minimum in control (69.287 mm). This increase in width might be due to direct role of zinc in hastening the process of cell division and cell elongation. Positive effect of zinc on fruit width was also reported by Singh et al., (2013). However, specific gravity was recorded highest in borax 1.5% followed by borax 2% while minimum in K₂SO₄ 1.0%.

Pulp and stone characteristics and Edible: Non-edible ratio

The maximum pulp weight was recorded in borax 2% (290.60 gm) followed by CaCl₂ 4% while the minimum pulp weight was found in control (213.66 gm). Boron increased fruit weight by more accumulation of photosynthates in the matured fruits. Result was in close conformity with Bhowmick et al., 2012; Karemera et al., 2014 and Bhusan and Panda, 2015. Whereas, maximum peel weight was recorded in control (37.13 gm) followed by K₂SO₄ 1.5% (38.55 gm) while minimum in CaCl₂ 4.0% (23.42 gm). The maximum stone weight was recorded in CaCl₂ 4.0% followed by CaCl₂ 8% while the minimum stone weight was found in control (Table-3).

From table-4 it was clear that maximum pulp percentage was recorded in borax 2% followed by CaCl₂ 4% and the minimum in K₂SO₄ 1.5%. Highest peel percentage was recorded in control (13.47%) followed by K₂SO₄ 1.5% (13.26%) while minimum peel percentage was found in CaCl₂ 4% (6.66%).

These finding of Bhusan et al., (2015) and Bhowmick et al., (2012) were showed similar result. The stone percentage was recorded highest in CaCl₂ 8% and minimum in K₂SO₄ 1% (Table-4). Fruit pulp: stone ratio was recorded highest in K₂SO₄ 1% followed by borax 2% while it was minimum in borax 1.5%. The maximum edible: non-edible ratio was recorded in borax 2% followed by CaCl₂ 4.0% (Table-3). Similar findings were observed by Karemeraa and Habimana, 2014).

Fruit quality attributes

Total soluble solids

The maximum TSS (21.08°B) was observed in borax 1% followed CaCl₂ 4% and minimum in control fruits (Table-5).

Increase in TSS by boron application attributed to the rapid mobilization of sugars and other soluble solids from leaves to developing fruits. These findings were in agreement with the findings of Bhowmick et al., (2012), Singh et al., (2012), Nehete et al., (2011) and Bhatt et al., (2012).

Titratable acidity (%)

A critical review of data (Table-5) indicated that the highest titratable acidity (0.29%) was found in untreated fruits whereas it was lowest (0.24%) in ZnSO₄ 0.8% as followed ZnSO₄ 0.2%. ZnSO₄ effectively reduced acidity by accumulation of more total soluble solids. Enzymatic reactions need Zn for transformation of carbohydrates, hexokinase activity and sugar conversion (Dutta and Dhua, 2002). Similar effect of zinc was found in other fruit crops such as aonla, mango etc. (Meena et al., 2014; Panday and Jain, 2014).

TSS: TA ratio

Foliar application of borax 1.0% had significantly highest TSS: TA ratio as compare to other treatments (table-5).
Table 1: Effect of chemicals on yield attributing characters of mango cv. Langra

| Treatments      | Total number of fruits/plant | Fruit weight (gm) | Yield/plant (kg) | Yield/ha (t)  |
|-----------------|------------------------------|-------------------|------------------|--------------|
| CaCl₂ (4.0%)    | 181.33<sup>bc</sup>         | 351.83<sup>ab</sup> | 63.79<sup>a</sup> | 6.37<sup>a</sup> |
| CaCl₂ (6.0%)    | 178.33<sup>de</sup>         | 339.60<sup>bc</sup> | 60.56<sup>ab</sup> | 6.05<sup>ab</sup> |
| CaCl₂ (8.0%)    | 176.00<sup>def</sup>        | 324.23<sup>eg</sup> | 56.96<sup>bc</sup> | 5.69<sup>bc</sup> |
| K₂SO₄ (1.0%)    | 174.67<sup>ef</sup>         | 334.83<sup>de</sup> | 58.47<sup>abc</sup> | 5.84<sup>abc</sup> |
| K₂SO₄ (1.5%)    | 168.00<sup>g</sup>          | 275.73<sup>l</sup>  | 46.30<sup>e</sup>  | 4.63<sup>e</sup>  |
| K₂SO₄ (2%)      | 165.67<sup>g</sup>          | 295.36<sup>i</sup>  | 48.94<sup>e</sup>  | 4.89<sup>e</sup>  |
| Borax (1.0%)    | 191.33<sup>a</sup>          | 312.36<sup>fgh</sup>| 59.76<sup>abc</sup>| 5.97<sup>abc</sup>|
| Borax (1.5%)    | 184.33<sup>b</sup>          | 325.28<sup>def</sup>| 59.96<sup>abc</sup>| 5.99<sup>abc</sup>|
| Borax (2.0%)    | 173.67<sup>f</sup>          | 353.07<sup>a</sup>  | 61.28<sup>ab</sup> | 6.12<sup>ab</sup> |
| ZnSO₄ (0.2%)    | 164.33<sup>g</sup>          | 307.66<sup>hi</sup>| 50.55<sup>ed</sup> | 5.05<sup>ed</sup> |
| ZnSO₄ (0.4%)    | 176.00<sup>g</sup>          | 311.33<sup>gh</sup>| 54.81<sup>cd</sup> | 5.48<sup>cd</sup> |
| ZnSO₄ (0.8%)    | 180.33<sup>bc</sup>         | 338.00<sup>cd</sup>| 60.95<sup>ab</sup> | 6.09<sup>ab</sup> |
| Control         | 140.00<sup>h</sup>          | 276.08<sup>j</sup>  | 38.65<sup>f</sup>  | 3.86<sup>f</sup>  |

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan’s Multiple Range Test).

Table 2: Effect of chemicals on fruit growth and specific gravity of mango cv. Langra

| Treatments      | Fruit length (mm) | Fruit width (mm) | Fruit volume (cc) | Specific gravity |
|-----------------|-------------------|------------------|------------------|------------------|
| CaCl₂ (4.0%)    | 101.30<sup>a</sup> | 78.28<sup>abc</sup> | 348.35<sup>a</sup> | 1.01<sup>a</sup> |
| CaCl₂ (6.0%)    | 96.79<sup>ab</sup> | 77.15<sup>abc</sup> | 336.28<sup>bc</sup> | 1.01<sup>a</sup> |
| CaCl₂ (8.0%)    | 95.85<sup>ab</sup> | 73.85<sup>cde</sup> | 324.23<sup>de</sup> | 1.00<sup>a</sup> |
| K₂SO₄ (1.0%)    | 95.65<sup>ab</sup> | 75.74<sup>abcd</sup> | 341.66<sup>ab</sup> | 0.98<sup>a</sup> |
| K₂SO₄ (1.5%)    | 91.41<sup>bc</sup> | 70.51<sup>de</sup>  | 275.73<sup>h</sup>  | 1.00<sup>a</sup> |
| K₂SO₄ (2%)      | 91.27<sup>bc</sup> | 70.49<sup>de</sup>  | 298.35<sup>g</sup>  | 0.99<sup>a</sup> |
| Borax (1.0%)    | 98.75<sup>a</sup>  | 71.69<sup>de</sup>  | 309.34<sup>f</sup>  | 1.01<sup>a</sup> |
| Borax (1.5%)    | 100.23<sup>a</sup> | 75.08<sup>bcd</sup> | 318.90<sup>f</sup>  | 1.02<sup>a</sup> |
| Borax (2.0%)    | 99.28<sup>a</sup>  | 70.58<sup>de</sup>  | 346.15<sup>a</sup>  | 1.02<sup>a</sup> |
| ZnSO₄ (0.2%)    | 98.96<sup>a</sup>  | 78.08<sup>abc</sup> | 304.62<sup>gf</sup> | 1.01<sup>a</sup> |
| ZnSO₄ (0.4%)    | 99.29<sup>a</sup>  | 79.64<sup>ab</sup>  | 305.23<sup>gf</sup> | 1.02<sup>a</sup> |
| ZnSO₄ (0.8%)    | 100.12<sup>a</sup> | 80.81<sup>a</sup>  | 331.37<sup>cde</sup>| 1.02<sup>a</sup> |
| Control         | 89.69<sup>c</sup>  | 69.28<sup>e</sup>  | 273.35<sup>h</sup>  | 1.01<sup>a</sup> |

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan’s Multiple Range Test).
### Table 3: Effect of chemicals on edible and non-edible portion of mango cv. Langra

| Treatments   | Pulp weight (gm) | Peel weight (gm) | Stone weight (gm) | Edible: non-edible ratio | Pulp: Stone ratio |
|--------------|------------------|------------------|-------------------|--------------------------|-------------------|
| CaCl₂ (4.0%) | 289.40<sup>a</sup> | 23.42<sup>g</sup> | 39.01<sup>a</sup> | 4.63: 1<sup>ab</sup> | 7.42:1<sup>cde</sup> |
| CaCl₂ (6.0%) | 277.18<sup>ab</sup> | 26.12<sup>gc</sup> | 36.30<sup>abc</sup> | 4.44: 1<sup>abc</sup> | 7.64:1<sup>de</sup> |
| CaCl₂ (8.0%) | 261.8<sup>cd</sup> | 24.33<sup>g</sup> | 38.09<sup>a</sup> | 4.20: 1<sup>bcd</sup> | 6.88:1<sup>e</sup> |
| K₂SO₄ (1.0%) | 272.41<sup>bc</sup> | 33.56<sup>b</sup> | 28.86<sup>cf</sup> | 4.37: 1<sup>abcd</sup> | 9.45:1<sup>a</sup> |
| K₂SO₄ (1.5%) | 213.27<sup>g</sup> | 36.55<sup>b</sup> | 25.91<sup>gh</sup> | 4.37: 1<sup>abcd</sup> | 9.45:1<sup>a</sup> |
| K₂SO₄ (2%)   | 232.95<sup>l</sup> | 30.98<sup>bcd</sup> | 31.45<sup>def</sup> | 3.74: 1<sup>ef</sup> | 7.13:1<sup>de</sup> |
| Borax (1.0%) | 250.07<sup>de</sup> | 28.61<sup>def</sup> | 33.68<sup>bcd</sup> | 4.03: 1<sup>bcde</sup> | 7.52:1<sup>cde</sup> |
| Borax (1.5%) | 262.86<sup>cd</sup> | 25.55<sup>g</sup> | 36.87<sup>a</sup> | 4.68: 1<sup>a</sup> | 8.96:1<sup>abc</sup> |
| Borax (2.0%) | 290.60<sup>a</sup> | 29.12<sup>cd</sup> | 33.68<sup>bc</sup> | 4.41: 1<sup>abcd</sup> | 8.27:1<sup>abc</sup> |
| ZnSO₄ (0.2%) | 245.24<sup>ef</sup> | 32.67<sup>b</sup> | 29.75<sup>ef</sup> | 3.93: 1<sup>de</sup> | 8.25:1<sup>abcd</sup> |
| ZnSO₄ (0.4%) | 248.91<sup>ef</sup> | 30.56<sup>bcd</sup> | 31.86<sup>def</sup> | 3.98: 1<sup>cde</sup> | 7.81:1<sup>bcd</sup> |
| ZnSO₄ (0.8%) | 275.55<sup>bc</sup> | 29.12<sup>cd</sup> | 33.33<sup>cd</sup> | 4.41: 1<sup>abcd</sup> | 8.27:1<sup>abc</sup> |
| Control      | 213.66<sup>g</sup> | 37.13<sup>a</sup> | 25.29<sup>h</sup> | 3.43: 1<sup>f</sup> | 8.46:1<sup>abc</sup> |

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan’s Multiple Range Test).

### Table 4: Effect of chemicals on pulp, peel and stone proportion of mango cv. Langra

| Treatments   | Pulp (%) | Peel (%) | Stone (%) |
|--------------|----------|----------|-----------|
| CaCl₂ (4.0%) | 82.25<sup>a</sup> | 6.65<sup>g</sup> | 11.09<sup>abc</sup> |
| CaCl₂ (6.0%) | 81.62<sup>ab</sup> | 7.69<sup>efg</sup> | 10.69<sup>abcd</sup> |
| CaCl₂ (8.0%) | 80.75<sup>ab</sup> | 7.50<sup>fg</sup> | 11.75<sup>a</sup> |
| K₂SO₄ (1.0%) | 81.36<sup>ab</sup> | 10.02<sup>bc</sup> | 8.61<sup>g</sup> |
| K₂SO₄ (1.5%) | 77.34<sup>d</sup> | 13.26<sup>a</sup> | 9.40<sup>fg</sup> |
| K₂SO₄ (2%)   | 78.87<sup>cd</sup> | 10.48<sup>a</sup> | 10.64<sup>abcd</sup> |
| Borax (1.0%) | 80.05<sup>bc</sup> | 9.16<sup>cd</sup> | 10.78<sup>ab</sup> |
| Borax (1.5%) | 80.81<sup>ab</sup> | 7.86<sup>ef</sup> | 11.33<sup>ab</sup> |
| Borax (2.0%) | 82.30<sup>a</sup> | 8.48<sup>def</sup> | 9.216<sup>fg</sup> |
| ZnSO₄ (0.2%) | 79.71<sup>bc</sup> | 10.62<sup>b</sup> | 9.669<sup>defg</sup> |
| ZnSO₄ (0.4%) | 79.91<sup>bc</sup> | 9.83<sup>bc</sup> | 10.25<sup>bcd</sup> |
| ZnSO₄ (0.8%) | 81.51<sup>ab</sup> | 8.62<sup>de</sup> | 9.87<sup>cdefg</sup> |
| Control      | 77.35<sup>d</sup> | 13.47<sup>a</sup> | 9.18<sup>ef</sup> |

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan’s Multiple Range Test).
Table 5 Effect of chemicals on TSS, titratable acidity and sugar content of mango cv. Langra

| Treatments          | TSS (°B)  | Titratable Acidity (%) | TSS:TA ratio | Total sugars content (%) |
|---------------------|-----------|------------------------|---------------|--------------------------|
| CaCl₂ (4.0%)        | 20.64 a   | 0.27 bc                | 76.45:1 c     | 11.93 a                  |
| CaCl₂ (6.0%)        | 19.98 b   | 0.26 cd                | 76.97:1 c     | 11.08 b                  |
| CaCl₂ (8.0%)        | 19.84 bc  | 0.26 cd                | 76.37:1 c     | 10.47 bc                 |
| K₂SO₄ (1.0%)        | 20.02 b   | 0.28 ab                | 71.53:1 d     | 7.65 e                   |
| K₂SO₄ (1.5%)        | 20.18 b   | 0.26 ed                | 77.68:1 c     | 7.31 ef                  |
| K₂SO₄ (2%)          | 19.78 bc  | 0.28 ab                | 70.67:1 d     | 7.19 ef                  |
| Borax (1.0%)        | 21.08 a   | 0.25 de                | 84.39:1 a     | 12.04 a                  |
| Borax (1.5%)        | 20.87 a   | 0.26 cd                | 80.31:1 abc   | 11.87 a                  |
| Borax (2.0%)        | 20.16 b   | 0.26 cd                | 77.59:1 c     | 11.00 b                  |
| ZnSO₄ (0.2%)        | 19.06 ed  | 0.24 e                 | 79.50:1 abc   | 9.47 d                   |
| ZnSO₄ (0.4%)        | 19.46 cd  | 0.25 de                | 77.91:1 bc    | 9.48 d                   |
| ZnSO₄ (0.8%)        | 19.88 bc  | 0.24 e                 | 82.87:1 ab    | 10.11 c                  |
| Control             | 18.98 e   | 0.29 a                 | 65.47:1 e     | 6.85 f                   |

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan’s Multiple Range Test)

Table 6 Effect of chemicals on, carotenoids, ascorbic acid, phenolics content and antioxidant activity of mango cv. Langra

| Treatments          | Total carotenoids (mg/100 gm FW) | Ascorbic acid (mg/100gm FW) | Total phenolics(mg GAE/g FW) | Antioxidant activity (µmol TE/g FW) |
|---------------------|----------------------------------|-----------------------------|-------------------------------|-------------------------------------|
| CaCl₂ (4.0%)        | 1.56 c                           | 72.33 ab                    | 6.20 ab                       | 4.68 a                              |
| CaCl₂ (6.0%)        | 1.44 g                           | 70.12 bc                    | 5.90 bc                       | 4.26 a                              |
| CaCl₂ (8.0%)        | 1.46 f                           | 68.44 cd                    | 5.70 cd                       | 4.74 a                              |
| K₂SO₄ (1.0%)        | 1.52 d                           | 64.23 c                     | 5.60 bcd                      | 4.71 a                              |
| K₂SO₄ (1.5%)        | 1.50 f                           | 64.67 c                     | 4.93 g                        | 4.51 a                              |
| K₂SO₄ (2%)          | 1.42 h                           | 62.25 ef                    | 5.23 def                      | 4.71 a                              |
| Borax (1.0%)        | 1.64 a                           | 75.26 a                     | 6.34 a                        | 5.16 a                              |
| Borax (1.5%)        | 1.58 b                           | 68.67 c                     | 5.60 bcd                      | 5.03 a                              |
| Borax (2.0%)        | 1.55 c                           | 73.33 ab                    | 5.50 cdef                     | 4.98 a                              |
| ZnSO₄ (0.2%)        | 1.58 b                           | 63.98 c                     | 4.90 g                        | 5.10 a                              |
| ZnSO₄ (0.4%)        | 1.52 d                           | 64.33 c                     | 5.20 defg                     | 4.98 a                              |
| ZnSO₄ (0.8%)        | 1.46 f                           | 65.28 de                    | 5.00 fg                       | 4.68 a                              |
| Control             | 1.41 h                           | 60.22 f                     | 4.60 g                        | 4.03 a                              |

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan’s Multiple Range Test)
Total sugars

Significant variation was recorded among various treatments with respect to sugar content and clearly revealed in table-5. Total sugar gradually increased in all the treatment than that of control. The maximum total sugar content (12.04%) was recorded in borax 1% followed by CaCl₂ 4% while minimum (6.85%) was found in control.

Boron facilitates sugar transport within plants and reacts with sugar to form a sugar borate complex which reduces its consumption during metabolic processes (Gauch and Dugger, 1953; Stamper et al., 1999; Rajput and Chand, 1976). These results were supported by results obtained earlier by Nehete et al., 2011; Bhatt et al., 2012; Gaur et al., 2014.

Total carotenoids

The data illustrated in table-6 showed that all the treatments significantly influenced total carotenoids content. Highest total carotenoids was observed in borax 1% (1.64 mg/100 gm) followed by borax 1.5% whereas the least total carotenoids was recorded in control (1.41 mg/100 gm FW).

Total phenolic content

Highest total phenolic content (6.34 mg GAE/100g FW) was observed in borax 1% followed by CaCl₂ 4% whereas it was lowest in control (4.60 mg GAE/100g FW). High boron concentration resulted in the increase of gene expression and enzyme activities involved in phenolic biosynthesis (Song et al., 2015). The result was accordance with earlier reports of Herrera-Rodriguez et al., 2010 and Davarpanah et al., 2015.

Total antioxidant activity

Antioxidant activity increases in all treatments with no significant differences between treated and untreated fruit. However, the data shown in table-6 indicated that among treatments, borax 1% had comparatively highest antioxidant activity (5.16 μmol Trolox equivalent/100g FW). Similar results were found in blue berry and pomegranate (Merino-Gergichevich et al., 2016; Davarpanah et al., 2015).

On the basis of results summarized above, it can be concluded that foliar application of calcium, potassium, boron and zinc showed significant variation in yield, fruit development, and its quality attributes of the mango cv. Langra.

Present investigation concluded that borax @ 1% and CaCl₂@ 4% was most efficient treatment for enhancing yield and retaining the quality of mango fruits.

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