ISSN: 0976-1675

www.rjas.org

Research Journal of Agricultural Sciences

Research Paper

DI: 6012-0503-144

Effect of Pre-harvest Macro and Micronutrients on Quality and Postharvest Behaviour of Mango (*Mangifera Indica* L.) Cv. Langra

Anugya Kumari[1], Manoj Kundu[2], Rewati Raman Singh[3] and Deep Lata[4*]
Department of Fruit and Fruit Technology,
Bihar Agricultural University, Sabour - 813 210, Bhagalpur, Bihar, India

Received: 05 March 2020; Revised accepted: 25 May 2020

ABSTRACT

Mango is one of the most popular fruit crop of India having high nutritional value. Among the all cultivars Langra is most popular under North Indian conditions. But it has shorter shelf life of 4-5 days. The present investigation was carried out to assess the effect of nutrients on yield, quality as well as postharvest behaviour of Cv. Langra. The treatments included $CaCl_2$ @ 4%,$CaCl_2$ @ 6%, $CaCl_2$ @ 8%, K_2SO_4 @ 1.0%, K_2SO_4 @ 1.5%, K_2SO_4 @ 2.0%, Borax @ 1.0%, Borax @ 1.5%), Borax @ 2.0%, $ZnSO_4$ @ 0.2%, $ZnSO_4$ @ 0.4%, $ZnSO_4$ @ 0.8%. Pre-harvest application was done at 30 days before harvest and fruits were evaluated at intervals of 3, 5, 7 and 10 days after ambient temperature storage. The foliar application of macro and micronutrients had immense potential to increase the quality as well as shelf life of fruits. Results showed that calcium chloride (4.0%) was found best in reducing weight loss along with minimum decay on the 10^{th} day of storage. However, borax (1%) effectively maintained other quality attributes like TSS, sugar, total carotenoids, ascorbic acid till 10 days of storage. Therefore, $CaCl_2$ & Borax could be an effective treatment for enhancing yield and postharvest quality.

Key words: Mango, Calcium chloride, Borax, Decay, Postharvest quality

Mango often referred as "National fruit of India" as well as "king of fruits "is one of the most popular fruit crop of India. It has high nutritive value, excellent flavour, pleasant aroma, rich source of vitamin A and minerals. Among the various cultivars recommended for north Indian conditions, Langra is most popular due to its luscious taste. Fruit has excellent potential for export as fresh fruit as well as in the form of processed products. Demand of Langra as fresh fruits and its processed products are increasing in domestic as well as international market both. It is well known that mango is highly perishable and under north Indian condition its ripening coincides with summer season one of the reason for shorter shelf life. Although, India is largest producer but its share in export is only 0.38% (Kusumua and Basavaraja 2014). Major constraints which hinders its export are its very short shelf life at ambient condition and huge post-harvest losses. The international as well as the domestic market is facing several issues regarding postharvest management of fruits at different stages (Malik *et al*. 2010).

In many research studies, it has been found that application of calcium along with potassium among macronutrients as well as zinc and boron among micronutrients exhibit remarkable effect on reducing the postharvest losses by enhancing the quality and shelf-life. Potassium plays an important role in the interaction of metabolic events involved in fruit ripening as well as senescence. It helps in cell growth by cell expansion and development of thick epidermal cell walls (Salisbury and Ross 1992). Calcium considered as an important plant nutrient which reduces the weight loss, delays ripening, increases the shelf life by maintaining firmness, reduced respiration rate, ethylene evolution rate and also delay fruit rot (Karameros and Habitant 2014). Boron improves translocation of sugar, lignification, cell wall structure and maintains fruit quality by lowering respiration rate (Blevins and Lukaszewski 1998, Bhat *et al*. 2012). Zinc is an essential trace element for plants and essential for many enzymatic reactions, regulation of protein and carbohydrate metabolism. It also improves the auxin content. Keeping

[1-3]Department of Fruit and Fruit Technology, Bihar Agricultural University, Sabour - 813 210, Bhagalpur, Bihar

[4*]Deep Lata, Ph. D. Scholar, (deeplata21@gmail.com), Division of Postharvest Technology and Agriculture Engineering, ICAR- Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru - 560 089, Karnataka

these aspects in view, present study was planned to evaluate the effect of pre-harvest application of calcium, potassium, boron and zinc on postharvest behaviour of mango fruits cv. Langra during 10 days storage at ambient condition.

MATERIALS AND METHODS

For experiment about 21 years old bearing, uniform vigour and size mango trees (*Mangifera indica* L.) cv. Langra were selected. All the trees were maintained under uniform cultural schedule during the course of investigation. The experiment was conducted in randomized block design (RBD) with thirteen treatments and replicated thrice each. The details of experimental treatments employed in the present investigation are as follow: T_1 ($CaCl_2$ @ 4%),T_2 ($CaCl_2$ @ 6%),T_3 ($CaCl_2$ @ 8%), T_4 (K_2SO_4 @ 1.0%), T_5 (K_2SO_4 @ 1.5%), T_6 (K_2SO_4 @ 2.0%), T_7 (Borax @ 1.0%), T_8 (Borax @ 1.5%), T_9 (Borax @ 2.0%),T_{10} ($ZnSO_4$ @ 0.2%), T_{11} ($ZnSO_4$ @ 0.4%), T_{12} ($ZnSO_4$ @ 0.8%) and T_{13} Control (Water spray). All chemicals were sprayed around 30 days before harvesting of fruits. The fruits were harvested and stored at ambient condition for further studies. All the quality parameters were evaluated at 3, 5, 7 and 10 days after storage. The Data were analyzed using statistical analysis software (SAS 9.2) and the means were compared using Duncan's multiple range test. Mean difference were tested by 'F' test at five per cent level of significance.

Physico-chemical parameters

Weight loss: For determination of weight loss, both treated and untreated fruits were weighed at 0 day and intervals of 3, 5, 7 and 10 days of storage. Then weight loss was calculated by subtracting initial weight from the final weight of the fruit divided by initial weight and expressed as percentage.

Percentage of rotten fruits: Rotting percent was estimated on the basis of symptoms of rot, irrespective of the severity. The fruits were evaluated at 3, 5, 7 and 10 days of storage. Then rotting was calculated by dividing number of rotted fruit by total no. of fruit under observation and expressed as percentage.

TSS, titratable acidity (TA) and TSS

TA ratio: Total soluble solids of the fruits were recorded at room temperature using hand refractometer and were expressed in terms of degree brix. Titratable acidity (TA) was determined by using standard titration method (AOAC 2000). TSS: TA ratio was calculated by dividing the respective values of TSS by titratable acidity.

Total, reducing and non-reducing sugars: Reducing and total sugar was determined by Lane and Eynone (1923) method and it was expressed in %. For estimating non-reducing sugar, the value of reducing sugar was subtracted from total sugar.

Total carotenoids and ascorbic acid content: Total carotenoids content was determined by using the method of Roy (1973) and result was expressed as mg 100 g^{-1} fresh weight (FW). Ascorbic acid content in the fruit was estimated by 2, 6-dichlorophenol indophenol dye method (Jones and Hughes 1983) and values were expressed in mg/100 g FW.

RESULTS AND DISCUSSION

Effect on weight loss

Weight loss was observed with increasing trend in all the treatments during entire storage period (Table 1). Among all the treatments, calcium chloride @ 4% was found as best treatment and showed minimum (19.23%) weight loss than control which exhibited highest (28.29%) weight loss during 10 days storage. The highest loss in weight of untreated fruits might be due to the upsurge in respiration rate and transpiration processes compared to calcium treated fruits. The decrease in weight loss by the application of calcium might be due to its consistency in the cell wall which resulted in higher fruit firmness, retardation of respiratory rate as well as delay in senescence. These observations are in accordance to the findings of Singh *et al.* (1993). Comparable results of calcium treatment on lower fruit weight loss have also been reported by Singh *et al.* (2012) in mango Cv. Dashehari and Bhusan and Panda (2015) in mango Cv. cv. Amrapali.

Table 1 Effect of chemicals on weight loss (%) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	6.18^{m}	10.33^{e}	15.35^{l}	19.23^{m}
T_2: Calcium Chloride (6.0%)	6.58^{k}	10.86^{de}	16.86^{j}	20.67^{k}
T_3: Calcium Chloride (8.0%)	7.02^{h}	11.28^{d}	17.84^{f}	22.37^{h}
T_4: Potassium Sulphate (1.0%)	7.56^{f}	12.88^{bc}	17.98^{e}	23.32^{e}
T_5: Potassium Sulphate (1.5%)	7.44^{g}	11.28^{d}	17.26^{h}	22.84^{f}
T_6: Potassium Sulphate (2%)	7.78^{e}	12.24^{c}	17.58^{g}	22.54^{g}
T_7: Borax (1.0%)	6.44^{l}	10.26^{e}	15.36^{l}	20.33^{l}
T_8: Borax (1.5%)	6.86^{j}	11.02^{ed}	16.60^{k}	21.40^{j}
T_9: Borax (2.0%)	6.92^{i}	11.23^{d}	17.02^{i}	21.96^{i}
T_{10}: Zinc Sulphate (0.2%)	8.12^{d}	12.56^{bc}	18.98^{d}	23.66^{d}
T_{11}: Zinc Sulphate (0.4%)	8.36^{c}	12.98^{bc}	19.29^{c}	25.52^{c}
T_{12}: Zinc Sulphate (0.8%)	8.48^{b}	13.26^{b}	19.84^{b}	26.02^{b}
T_{13}: Control (Water spray)	9.12^{a}	14.80^{a}	21.18^{a}	28.29^{a}

Value indicates mean of three replicates, Different letters in the same column indicate significant differences at $P \leq 0.05$ (Duncan's Multiple Range Test)

Effect on rotting percentage

Generally, the most vital physical character of ripe mango fruit is decay percentage which significantly influence marketability of fruits. Rotting percentage showed a continuous increase throughout the experiment as shown in (Table 2). Rotting was reduced significantly in all treatment. However, least (6.13%) rotting was observed in calcium chloride @ 4% while control fruits exhibited highest rotting percentage during 10 days storage at room temperature. One of the main reasons for decay of fruits during storage was infection of pathogens carried out from the field, increase in respiration and water loss. Calcium significantly thickened the middle lamella of fruit cells owing to increased deposition of calcium pectate and thereby maintained the cell wall, which inhibits the penetration and spread of pathogens in fruits ultimately reduce the rotting (Gupta *et al*. 1984). The higher rotting in control fruits might be due to high polygalacturonage and cellulase activities, resulted in fast degradation of protopectin and cellulose causing early softening of fruits (Roe and Bruemmer 1981). Similar findings were observed by Bhusan and Panda (2015) and Singh *et al*. (2008) in ber.

Table 2 Effect of chemicals on rotting (%) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	0.00	0.00	5.33^{bcd}	10.33^{cd}
T_2: Calcium Chloride (6.0%)	0.00	0.00	6.13^{bc}	12.67^{b}
T_3: Calcium Chloride (8.0%)	0.00	0.00	6.33^{b}	12.33^{bc}
T_4: Potassium Sulphate (1.0%)	0.00	0.00	4.66^{d}	8.67^{de}
T_5: Potassium Sulphate (1.5%)	0.00	0.00	5.33^{bcd}	8.33^{def}
T_6: Potassium Sulphate (2%)	0.00	0.00	5.33^{bcd}	7.87^{ef}
T_7: Borax (1.0%)	0.00	0.00	2.33^{e}	6.130^{f}
T_8: Borax (1.5%)	0.00	0.00	3.30^{e}	6.87^{ef}
T_9: Borax (2.0%)	0.00	0.00	2.67^{e}	6.33^{f}
T_{10}: Zinc Sulphate (0.2%)	0.00	0.00	5.13^{cd}	12.37^{bc}
T_{11}: Zinc Sulphate (0.4%)	0.00	0.00	5.67^{bcd}	11.89^{bc}
T_{12}: Zinc Sulphate (0.8%)	0.00	0.00	5.33^{bcd}	12.67^{b}
T_{13}: Control (Water spray)	0.00	0.00	23.33^{a}	50.00^{a}

Total soluble solids

Significant variation was recorded among various treatments with respect to TSS and it was revealed that the total soluble solids of mango fruit progressively increased in all treatments up to 7th day thereafter started decreasing 10th day of storage (Table 3). Higher TSS level (23.4°B) was retained by borax @ 1% while lowest value (22°B) was recorded in control during 10th day of storage. The increase in TSS during storage might be due to hydrolysis of starch into sugars and subsequently metabolized during respiration and level got decreased during further storage (Wills *et al*. 1980). Similar results had been recorded in many fruits such as guava (Dutta 2004), mango (Gaya 2008, Bhat *et al*. 2008) etc.

Table 3 Effect of chemicals on TSS (°B) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	23.87^{a}	24.58^{abcd}	24.67^{abcd}	22.16^{e}
T_2: Calcium Chloride (6.0%)	23.72^{ab}	24.46^{abcd}	24.61^{abcd}	22.42^{de}
T_3: Calcium Chloride (8.0%)	23.32^{cd}	24.18^{cd}	24.26^{cd}	22.12^{e}
T_4: Potassium Sulphate (1.0%)	22.58^{hg}	24.48^{abcd}	24.61^{abcd}	22.50^{cde}
T_5: Potassium Sulphate (1.5%)	22.96^{ef}	24.79^{ab}	24.85^{ab}	22.68^{bcd}
T_6: Potassium Sulphate (2%)	22.44^{h}	24.22^{cd}	24.36^{bcd}	23.06^{ab}
T_7: Borax (1.0%)	23.98^{a}	24.98^{a}	25.12^{a}	23.47^{a}
T_8: Borax (1.5%)	23.52^{bc}	24.67^{acd}	24.75^{abc}	23.38^{a}
T_9: Borax (2.0%)	23.16^{de}	24.41^{bcd}	24.67^{abcd}	23.34^{a}
T_{10}: Zinc Sulphate (0.2%)	22.76^{fg}	24.06^{d}	24.16^{d}	22.96^{abc}
T_{11}: Zinc Sulphate (0.4%)	22.88^{ef}	24.14^{cd}	24.28^{bcd}	23.03^{ab}
T_{12}: Zinc Sulphate (0.8%)	23.16^{de}	24.54^{abcd}	24.67^{abcd}	23.24^{a}
T_{13}: Control (Water spray)	21.16^{i}	23.20^{e}	23.42^{e}	22.02^{e}

Titratable acidity

The proportion of sugar and acid content in fruit pulp of mango determines its taste. The data pertaining to the titratable acidity revealed that the acidity of mango fruits decrease gradually in all the treatments with the advancement of the storage period. It might be due to the involvement of organic acids as respiratory substrate and due to increase in sugar content. The data presented in (Table 4) indicated that on 3rd, 5th and 7th day of storage, minimum acidity of mango fruits was observed in treatment zinc sulphate @ 0.4% (0.21%, 0.21% and 0.17%, respectively) whereas maximum acidity was recorded in calcium chloride @ 4.0% and control (0.24% and 0.27% respectively). While on 10th day of storage the minimum acidity (0.15%) of mango fruits was observed in the treatment of zinc sulphate @ 0.4% whereas maximum acidity (0.19%) of mango fruits was recorded in calcium chloride @ 8.0%. This finding confirms the earlier report of Bhowmick *et al.* (2012) in mango.

TSS/TA ratio

The results indicated that the TSS/TA ratio of mango fruits increase gradually in treatments as storage period exceed (Table 5). However, on 10th day of storage the maximum TSS/TA ratio of mango fruits were also observed in treatment potassium sulphate @ 0.4%. This is mainly due to rapid increase of TSS by the application of potassium sulphate @ 0.4% with gradual decrease of titratable acidity on 10th days of storage.

Table 4 Effect of chemicals on Titratable acidity (%) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	0.27^{a}	0.26^{ab}	0.24^{a}	0.18^{ab}
T_2: Calcium Chloride (6.0%)	0.24^{cd}	0.24^{cd}	0.21^{d}	0.17^{bc}
T_3: Calcium Chloride (8.0%)	0.25^{bc}	0.24^{cd}	0.22^{c}	0.19^{a}
T_4: Potassium Sulphate (1.0%)	0.24^{cd}	0.24^{cd}	0.22^{c}	0.16^{cd}
T_5: Potassium Sulphate (1.5%)	0.26^{ab}	0.24^{ab}	0.20^{e}	0.17^{bc}
T_6: Potassium Sulphate (2%)	0.26^{ab}	0.24^{cd}	0.21^{d}	0.15^{d}
T_7: Borax (1.0%)	0.25^{bc}	0.25^{bc}	0.21^{d}	0.16^{cd}
T_8: Borax (1.5%)	0.25^{bc}	0.23^{de}	0.19^{f}	0.15^{d}
T_9: Borax (2.0%)	0.26^{ab}	0.25^{bc}	0.22^{c}	0.17^{bc}
T_{10}: Zinc Sulphate (0.2%)	0.23^{d}	0.22^{ef}	0.18^{g}	0.16^{cd}
T_{11}: Zinc Sulphate (0.4%)	0.21^{e}	0.21^{f}	0.17^{g}	0.15^{d}
T_{12}: Zinc Sulphate (0.8%)	0.23^{d}	0.23^{de}	0.18^{g}	0.15^{d}
T_{13}: Control (Water spray)	0.27^{a}	0.27^{a}	0.23^{b}	0.18^{ab}

Table 5 Effect of chemicals on TSS: TA of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	$88.44{:}1^{ef}$	$94.59{:}1^{e}$	$102.86{:}1^{h}$	$123.33{:}1^{gf}$
T_2: Calcium Chloride (6.0%)	$98.91{:}1^{bc}$	$102.03{:}1^{cd}$	$117.36{:}1^{ef}$	$132.18{:}1^{ef}$
T_3: Calcium Chloride (8.0%)	$93.36{:}1^{cde}$	$100.90{:}1^{d}$	$110.39{:}1^{g}$	$116.61{:}1^{g}$
T_4: Potassium Sulphate (1.0%)	$94.20{:}1^{bcde}$	$102.07{:}1^{cd}$	$111.95{:}1^{fg}$	$141.75{:}1^{cde}$
T_5: Potassium Sulphate (1.5%)	$88.37{:}1^{ef}$	$103.29{:}1^{cd}$	$124.29{:}1^{d}$	$133.71{:}1^{def}$
T_6: Potassium Sulphate (2%)	$86.44{:}1^{f}$	$101.760{:}1^{cd}$	$116.11{:}1^{d}$	$154.12{:}1^{ab}$
T_7: Borax (1.0%)	$96.00{:}1^{bcd}$	$99.99{:}1^{d}$	$120.11{:}1^{de}$	$147.05{:}1^{abc}$
T_8: Borax (1.5%)	$94.20{:}1^{bcde}$	$107.31{:}1^{bc}$	$130.38{:}1^{c}$	$156.25{:}1^{a}$
T_9: Borax (2.0%)	$89.16{:}1^{def}$	$97.69{:}1^{de}$	$112.20{:}1^{fg}$	$137.48{:}1^{cde}$
T_{10}: Zinc Sulphate (0.2%)	$99.04{:}1^{bc}$	$109.48{:}1^{b}$	$134.45{:}1^{bc}$	$143.79{:}1^{bcd}$
T_{11}: Zinc Sulphate (0.4%)	$109.05{:}1^{a}$	$115.08{:}1^{a}$	$143.07{:}1^{a}$	$153.93{:}1^{ab}$
T_{12}: Zinc Sulphate (0.8%)	$100.84{:}1^{b}$	$106.80{:}1^{bc}$	$137.30{:}1^{b}$	$155.30{:}1^{a}$
T_{13}: Control (Water spray)	$78.42{:}1^{g}$	$85.97{:}1^{f}$	$101.91{:}1^{h}$	$123.28{:}1^{gf}$

Table 6 Effect of chemicals on Total sugars (%) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	15.423^{bc}	17.61^{cd}	18.08^{cd}	15.40^{c}
T_2: Calcium Chloride (6.0%)	14.901^{c}	17.07^{de}	17.24^{de}	14.81^{c}
T_3: Calcium Chloride (8.0%)	14.088^{d}	16.69^{e}	16.96^{e}	14.02^{d}
T_4: Potassium Sulphate (1.0%)	10.033^{f}	12.00^{h}	13.41^{g}	11.13^{f}
T_5: Potassium Sulphate (1.5%)	10.025^{g}	13.23^{g}	13.72^{g}	11.38^{f}
T_6: Potassium Sulphate (2%)	9.786^{g}	12.21^{h}	12.89^{gh}	10.67^{fg}
T_7: Borax (1.0%)	16.195^{a}	20.41^{a}	20.98^{a}	17.74^{a}
T_8: Borax (1.5%)	15.725^{ab}	18.85^{b}	19.35^{b}	16.72^{b}
T_9: Borax (2.0%)	14.857^{c}	17.71^{c}	18.40^{bc}	16.30^{b}
T_{10}: Zinc Sulphate (0.2%)	12.176^{e}	13.67^{g}	15.25^{f}	13.03^{e}
T_{11}: Zinc Sulphate (0.4%)	12.178^{e}	13.55^{g}	15.25^{f}	12.37^{e}
T_{12}: Zinc Sulphate (0.8%)	13.185^{e}	15.33^{f}	15.85^{f}	13.13^{e}
T_{13}: Control (Water spray)	9.147^{g}	10.75^{i}	12.25^{h}	9.96^{g}

Total, reducing and non-reducing sugar

The data pertaining sugar content was critically evaluated and it was observed that the sugar content of mango fruits increased gradually with the advancement of the storage period up to the 7th day and thereafter it decreased up to 10th day of storage. The data presented in (Table 6) revealed that on 10th day of storage, the maximum total sugar content was recorded in borax @ 1.0% (17.74%) whereas it was minimum in control (9.96%). These results are in close conformity with the findings of Gaur *et al*. (2014) and Bhusan and Panda (2015).

Highest reducing sugar content was also observed in borax @ 1.0% (Table 7). Similar effect of borax was observed in different studies (Gaya 2008, Bhat *et al*. 2008, Bhat *et al*. 2012). Boron facilitates sugar transport within the plants and it was reported that borate reacts with sugar to form a sugar borate complex (Gauch and Dugger 1953). Conversion of starches and polysaccharides into simple sugar with the advancement of storage was responsible for the increase of reducing sugar, and onward decline was due to the utilization of sugar in several biochemical processes (Kahlon and Uppal 2005).

Table 7 Effect of chemicals on Reducing sugars (%) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	5.76^{b}	6.43^{b}	6.68^{b}	5.46^{b}
T_2: Calcium Chloride (6.0%)	5.49^{c}	6.25^{b}	6.33^{c}	5.21^{bc}
T_3: Calcium Chloride (8.0%)	5.12^{d}	6.02^{c}	6.21^{c}	5.08^{bc}
T_4: Potassium Sulphate (1.0%)	3.98^{g}	4.88^{gh}	5.22^{fg}	4.48^{de}
T_5: Potassium Sulphate (1.5%)	3.72^{h}	4.98^{fg}	5.39^{f}	4.55^{de}
T_6: Potassium Sulphate (2%)	3.66^{h}	4.71^{h}	5.02^{g}	4.23^{e}
T_7: Borax (1.0%)	5.67^{b}	6.96^{a}	7.27^{a}	6.18^{a}
T_8: Borax (1.5%)	6.02^{a}	6.92^{a}	7.18^{a}	6.07^{a}
T_9: Borax (2.0%)	5.52^{c}	6.84^{a}	7.01^{ab}	6.00^{a}
T_{10}: Zinc Sulphate (0.2%)	4.26^{f}	5.36^{e}	5.76^{de}	4.56^{de}
T_{11}: Zinc Sulphate (0.4%)	4.02^{g}	5.16^{ef}	5.48^{ef}	4.39^{e}
T_{12}: Zinc Sulphate (0.8%)	4.88^{e}	5.69^{d}	6.02^{cd}	4.88^{cd}
T_{13}: Control (Water spray)	3.21^{i}	4.04^{i}	4.29^{h}	3.18^{f}

Data presented in (Table 8) showed that on 3rd, 5th and 7th day of storage, highest non-reducing sugar content was reported in borax @ 1% (9.98%, 12.77% and 10.98%, respectively) whereas minimum total non-reducing sugar content was recorded in control and potassium sulphate @ 2%. On 10th day of storage, same pattern was observed. These results elucidated the findings of Babu and Singh (2001), Dutta (2004) and Bhatt *et al*. (2012).

Table 8 Effect of chemicals on Non-reducing sugars (%) of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	9.18^{b}	10.62^{c}	10.83^{bc}	9.44^{cd}
T_2: Calcium Chloride (6.0%)	8.94^{b}	10.28^{c}	10.36^{c}	9.12^{d}
T_3: Calcium Chloride (8.0%)	8.52^{c}	10.14^{c}	10.21^{c}	8.48^{e}
T_4: Potassium Sulphate (1.0%)	5.75^{e}	7.62^{ef}	7.78^{e}	6.32^{g}
T_5: Potassium Sulphate (1.5%)	5.99^{e}	7.84^{e}	7.92^{e}	6.49^{g}
T_6: Potassium Sulphate (2%)	5.82^{e}	7.12^{f}	7.48^{e}	6.12^{g}
T_7: Borax (1.0%)	9.98^{a}	12.77^{a}	12.94^{a}	10.98^{a}
T_8: Borax (1.5%)	9.22^{b}	11.33^{b}	11.56^{b}	10.12^{b}
T_9: Borax (2.0%)	8.87^{bc}	10.32^{c}	10.82^{bc}	9.78^{bc}
T_{10}: Zinc Sulphate (0.2%)	7.52^{d}	8.94^{d}	9.02^{d}	8.05^{ef}
T_{11}: Zinc Sulphate (0.4%)	7.75^{d}	9.06^{d}	9.28^{d}	7.58^{f}
T_{12}: Zinc Sulphate (0.8%)	7.89^{d}	9.16^{d}	9.34^{d}	7.84^{f}
T_{13}: Control (Water spray)	5.64^{e}	7.16^{f}	7.56^{e}	6.44^{g}

Total carotenoids

The result indicated that total carotenoids gradually increase with the advancement of the storage period up to the 7th day and then after it started decreasing (Table 9). Highest value of carotenoid were recorded in treatment borax @ 1% and minimum in control followed by calcium chloride@ 6%. The increase in carotenoids might be because of calcium, zinc and boron treatments which increased the permeability of external tissue and activated the enzymatic activities which are responsible for carotene synthesis and hastened the ripening and development of colour. These findings are similar to Chauhan *et al.* (2014).

Table 9 Effect of chemicals on Total carotenoids of Mango Cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	1.86^{d}	2.12^{ab}	2.33^{de}	2.17^{ef}
T_2: Calcium Chloride (6.0%)	1.78^{f}	2.07^{b}	2.26^{f}	2.11^{g}
T_3: Calcium Chloride (8.0%)	1.79^{f}	2.09^{ab}	2.30^{def}	2.15^{gf}
T_4: Potassium Sulphate (1.0%)	1.84^{e}	2.16^{ab}	2.38^{bc}	2.21^{cde}
T_5: Potassium Sulphate (1.5%)	1.79^{f}	2.21^{a}	2.48^{a}	2.28^{b}
T_6: Potassium Sulphate (2%)	1.72^{g}	1.92^{c}	2.41^{b}	2.23^{c}
T_7: Borax (1.0%)	2.02^{a}	2.21^{a}	2.51^{a}	2.33^{a}
T_8: Borax (1.5%)	1.91^{b}	2.16^{ab}	2.34^{cd}	2.16^{f}
T_9: Borax (2.0%)	1.88^{c}	2.19^{ab}	2.48^{a}	2.22^{cd}
T_{10}: Zinc Sulphate (0.2%)	1.87^{cd}	2.11^{ab}	2.38^{bc}	2.18^{def}
T_{11}: Zinc Sulphate (0.4%)	1.83^{e}	2.07^{b}	2.29^{f}	2.14^{gf}
T_{12}: Zinc Sulphate (0.8%)	1.83^{e}	2.09^{ab}	2.31^{ed}	2.11^{g}
T_{13}: Control (Water spray)	1.64^{h}	1.89^{c}	2.09^{g}	1.78^{h}

Table 10 Effect of chemicals on Ascorbic acid (mg/100gm)of mango cv. Langra during storage

Treatments	Storage periods (Days)			
	3rd	5th	7th	10th
T_1: Calcium Chloride (4.0%)	126.347^{abc}	114.280^{a}	97.260^{bc}	91.670^{ab}
T_2: Calcium Chloride (6.0%)	122.560^{bcd}	109.540^{b}	93.130^{d}	89.560 ^{b}
T_3: Calcium Chloride (8.0%)	123.353^{bcd}	110.560^{ab}	94.870^{cd}	90.330^{ab}
T_4: Potassium Sulphate (1.0%)	120.330^{ed}	101.330^{cd}	84.160^{ef}	80.280^{c}
T_5: Potassium Sulphate (1.5%)	121.160^{cde}	103.670^{c}	86.110^{e}	79.930^{c}
T_6: Potassium Sulphate (2%)	118.080^{de}	100.580^{cd}	81.560^{f}	73.110^{d}
T_7: Borax (1.0%)	130.647^{a}	112.540^{ab}	102.670^{a}	94.330^{a}
T_8: Borax (1.5%)	122.880^{bcd}	108.650^{b}	100.560^{ab}	92.580^{ab}
T_9: Borax (2.0%)	127.590^{ab}	111.680^{ab}	101.230^{a}	93.130^{ab}
T_{10}: Zinc Sulphate (0.2%)	120.463^{ed}	104.150^{c}	91.370^{d}	81.590^{c}
T_{11}: Zinc Sulphate (0.4%)	120.637^{cde}	102.400^{cd}	93.330^{d}	84.340^{c}
T_{12}: Zinc Sulphate (0.8%)	121.220^{cde}	103.380 ^{c}	94.860c^{d}	82.570^{c}
T_{13}: Control (Water spray)	115.560^{e}	98.370^{d}	85.270^{e}	72.330^{d}

Ascorbic acid

Ascorbic acid is considered as an indicator of nutrition in addition to storage quality of fruits and vegetables. It acts as powerful antioxidant which prevents oxidative damages caused by reactive oxygen species. Ascorbic acid gradually declined in all treatments with increasing storage period (Table 10). During storage, oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase are responsible for decrease in ascorbic acid content of fruits (Singh *et al*. 2005). The highest ascorbic acid content (54.33 mg/100g) was observed in borax @ 1.0% whereas the lowest (32.33 mg/100 gm) in control fruits. Boron maintained higher ascorbic acid content might be due to higher content of sugars which helped in ascorbic acid synthesis. Similar pattern were reported by Kar *et al*. (2002) in pineapple, Singh *et al*. (2008) in ber and Bhat *et al*. 2012 in mango.

The pre-harvest application of macro and micro nutrients were found effective in retaining the quality as well as enhancing the shelf life of mango fruit. Among all treatments, calcium chloride @ 4.0% was the best which effectively reduced weight loss along with minimum decay at 10th day of storage. On the other hand, quality attributes like TSS, sugar, total carotenoids, ascorbic acid were retained maximum in borax @ 1%. Result of this study revealed that pre-harvest application of calcium and boron was highly efficient to maintain the overall quality and shelf life of fruits. Other nutrients such as potassium, zinc was also helpful in enhancing the quality and shelf life.

Acknowledgements

The authors are grateful to the Chairman, Department of Horticulture (Fruit and Fruit Technology), Bihar Agricultural University, Sabour, and Bhagalpur for providing necessary facilities as well as financial support to the present research work.

LITERATURE CITED

AOAC. 2000. Official Methods of Analysis, 17th Edition. Association of Official Analytical Chemists, Gaithersburg.

Babu N and Singh A R. 2001. Effect of foliar application of boron, zinc and copper on chemical characteristics of litchi (*Litchi chinensis* Sonn.) fruits. *Bioved* **12**(2): 45-48.

Bhatt A, Mishra N K, Mishra D K and Singh C P. 2012. Foliar application of potassium, calcium, zinc and boron enhanced yield, quality and shelf life of mango. *Horticultural Flora Research Spectrum* **1**(4): 300-305.

Bhatt A, Mishra N K, Singh C P and Lal R L. 2008. Studies on pre-harvest application of nutrients on yield, quality and shelf life of mango cv. Dashehari. *Progressive Horticulture* **40(**1): 41-47.

Bhowmick N, Banik B C, Hasan M A and Ghosh B. 2012. Response of pre-harvest foliar application of zinc and boron on mango cv. Amrapali under New Alluvial Zone of West Bengal. *Indian Journal of Horticulture Indian* **69**(3): 428-431.

Bhusan L P and Panda C. 2015. Effect of pre-harvest chemical treatments and mulching on quality of mango, *Mangifera indica* L cv. Amrapali. *International Journal of Farm Sciences* **5**(4): 132-138.

Bhusan L P, Panda C and Dash A K. 2015. Effect of pre-harvest chemical treatments and mulching on marketability of mango (*Mangifera indica* L.) cv. Amrapali. *Journal Crop and Weed* **11**(1): 216-219.

Blevins D G and Lukaszewski K M. 1998. Boron in plant structure and function. *Annual Review of Plant Physiology and Plant Molecular Biology* **49**: 481-500.

Chauhan B S, Shukla P K, Yadav L P and Verma D. 2014. Effect of pre-harvest foliar spray of Ca, Zn and B on respiration rate and biochemical change of Dasheheri mango during storage. *Asian Journal of Agriculture Marketing* **2**(1): 47-55.

Dutta P. 2004. Effect of foliar application on panicle growth, fruit retention and physicochemical characters of mango cv. Himsagar. *Indian Journal of Horticulture* **61**(30): 265-266.

Gauch H G and Duggar W M. 1953. The role of boron in the translocation of sucrose. *Plant Physiology* **28**: 457-466.

Gaur B, Beer K, Hada T S, Kanth, N and Syamal M M. 2014. Studies on the effect of foliar application of nutrients and GA_3 on fruit yield and quality of winter season guava. *The Ecoscan* **6**: 479-483.

Gaya. 2008. Effect of pre harvest foliar spray of nutrients on fruit quality and shelf life of mango cv. Dashehari. *M. Sc. Thesis*, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

Gupta D N, Lad B L, Chavan A S and Salvi M J. 1985. Enzyme studies on spongy tissue: A physiological ripening disorder in Alphonso mango. *Journal of Maharashtra Agricultural Universities* **10**: 280-282.

Jones E and Hughes R E. 1983. Foliar ascorbic acid in some angiosperms. *Phytochemistry* **22**: 2493-2499.

Kahlon P S and Uppal R S. 2005. Effect of postharvest treatments on shelf life of mango cv. Chausa. *Haryana Journal of Horticulture Science* **34**(2): 51-53.

Kar P L, Sema A, Maiti C S and Singh A K. 2002. Effect of zinc and boron on fruit and quality traits in pineapple (*Annanas comosus* L.). *South Indian Horticulture* **50**(3): 44-49.

Karameros N J U and Habitant S. 2014. Effect of calcium chloride sprays on ripening, shelf-life and physical chemical proprieties of mango fruits (*Mangifera indica* L.) cv.Totapuri. *Herald Journal of Agriculture and Food Science Research* **3**(2): 61-66.

Kusuma D K and Bhasavaraja H. 2014. Stability analysis of mango export markets of India: Markov chain approach. *Karnataka Journal of Agriculture Science* **27**(1): 36-39.

Lane J H and Eynon L. 1923. Determination of reducing sugars by means of Fehling's solution with methylene blue as internal indicator. *Journal* of the *Chemical Society Trans*. pp 32-36.

Malik A U, Hafeez O, Johnson P, Campbell J A, Amin M, Saeed M ,Mazahar, M S ,Sochuten S and Adeel J .2010. Towards developing a sea freight supply chain for delivering Pakistani mangoes to European market: Aprivate public sector model. *Acta Horticulture* **880**: 83-89.

Roe B and Bruemmer J H. 1981. Changes in pectic substance and enzyme during ripening and storage of ‘‘Keitt’’ mango. *Journal of Food Science* **54**: 186-189.

Roy S K. 1973. A simple and rapid method for estimation of total carotenoid pigments in mango. *Journal of Food Science and Technology* **10**: 38-42.

Salisbury F B and Ross C W. 1992. *Plant Physiology and Plant Cells*: *Plant Physiology*. Wadsworth, Belmont, California.

Singh A K, Singh C P and Chauhan P. 2012. Effect of pre-harvest chemical treatments and mulching on quality and marketability of Dashehari mango. *Indian Journal of Horticulture* **69**(4): 462-466.

Singh B P, Tandon D K and Kalra S K. 1993. Changes in post-harvest quality of mangoes affected by pre-harvest application of calcium salt. *Scientia Horticulturae* **5**(3): 211-219.

Singh S, Singh A K, Joshi H K, Bagle B G and Dhandar D G. 2008. Storability of ber (*Zizyphus mauritiana* Lamk) fruit in semiarid environment. *Journal of Food Science and Technology* **45**: 65-69.

Wills R B H, Bembridge PA and Scott K J. 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of ‘Delicious’ apples. *Australian Journal* of *Experimental* Agriculture and *Animal Husbandry* **20**: 252-256.