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Full Length Research Paper

Effect of pre-harvest foliar spray of Ca, Zn and B on respiration rate and biochemical changes of 'Dashehari' mango during storage

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To examine the role of pre-harvest foliar application of Ca, Zn and B on respiration rate and biochemical changes during storage of mango fruit was investigated. Test chemicals (Ca, Zn and B) significantly reduced the respiration rate as compared to untreated ones. In untreated fruits climacteric peak appeared at about 6th days, while in treated fruit it occurred at about 9th days of storage. Treated fruits had delayed ripening for about 3 days as compared to control. An increase in TSS and carotenoids was noted up to 9th days of storage under all treatments, thereafter, value of TSS and carotenoids slightly decreased. The tannin, starch and pectin contents were decreased gradually as the storage advanced. However, the fruits received the treatments of Ca, Zn and B showed higher retention of tannins, starch and pectin in both fresh and stored fruits.

Key words: Calcium, zinc, boron, respiration rate, storage, fruit ripening, mango.

INTRODUCTION

The mango (*Mangifera indica* L.) is the special product that substantiates the high standards of quality and bountiful of nutrients packed in it. It is well known for high antioxidant value (O'Neil, 2014) and variety of phytochemicals (Ajila and Prasad Rao, 2008). Dashehari is one of the leading commercial varieties of North India, known for the excellent quality of its fruits (Pradeepkumar et al., 2008). Its ripened pulp is very delicious and nutritious. A single mango can provide up to 40 per cent of daily dietary fibre, a potent protector against heart disease, cancer and cholesterol build-up. In addition to it, this luscious fruit is supposed to be a warehouse of potassium, beta-carotene and antioxidants (Anon, 2009). The carotenoid pigments, β-carotene (pro Vit-A), increases with ripening, whereas vitamin C registers a sharp fall with ripening (Soule and Hatton, 1955). The proper nutritional management plays a vital role in increasing the yield and quality of fruits. The foliar application of Ca and micro element exhibits its remarkable effect on physico-chemical attribute of fruits. Fruit quality as evident by T.S.S. and sugar content improved markedly by the application of zinc and boron in mango plants (Banik et al., 1997). The exact role of calcium, like that of all minerals, is still obscure, but it is important for cell wall development. Calcium ions delay the senescence by stabilizing cell membrane and increasing the stiffness of monolayer. The Ca^{2+} arbitrated cross linking may occur as bridging between phospholipids and carboxyl tails of embedded membrane protein (Leshem, 1991). There are also several calcium pectate interactions, which make the cell wall firmer (Carpita and McCann, 2000).

Calcium is associated with pectin substances in the middle lamella and with membranes generally and may slow the processes like respiration, softening and overall fruit ripening reduce losses and increase shelf life nearly by strengthening structural components of the cell without alleviating the original cause of cell collapse. Jones and Lunt (1967) reported that calcium is known to be an essential plant nutrient involved in a number of physiologi-

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cal processes concerning membrane structure and function and enzyme activity. Boron acts as catalyst or reaction regulator. It can delay the calcium deficiency but cannot replace calcium and it tends to keep calcium soluble. It may act as a regulator of potassium/calcium and the absorption of nitrogen. It may be concerned with oxidation-reduction equilibrium in cells.

Zinc improves the auxin content and it also acts as catalyst in oxidation-reduction processes. Nijjar et al. (1976) reported that the activity of carbonic anhydrase, a metallo enzyme for zinc, which is correlated with zinc content of leaves, exhibited a remarkable recovery when leaves are sprayed with zinc sulphate. In their experiment the zinc-deficient leaves produced only 418 μg carbondioxide/100 μg zinc in leaves/5 minutes where as in sprayed leaves it rose to 550 μg, thus, indicating that the spray of 0.2 and 0.4 per cent of zinc sulphate almost restored the normal activity of enzyme.

The nutritive value and quality of fruits, which depend on physical and biochemical changes that occur during ripening, storage and transportation, is very important from economic as well as academic point of view. Work on important problems of mango industry has been started systematically at several places in the country, but still a lot of work is needed on post-harvest management. In order to have good return and to avoid glut of mango fruits in market in the peak season it becomes essential to store the quality fruits for a considerable period. However, the marketability of fruits is lost rapidly owing to quick softening and rotting of fruits. It is reported that calcium, zinc and boron improve the quality and shelf life of mango fruits. In view of the above effect of pre-harvest foliar spray of Ca, Zn and B on the respiration rate and biochemical changes in mango fruits during storage was studied.

MATERIALS AND METHODS

Plant material

The 20 years old heavy bearer trees of cv. Dashehari having uniform vigour and productivity were selected for experiment at the research block of mango orchard of Janta College, Bakewar, Etawah (U.P.). Trees, those had not been sprayed in 1st year were selected for 2nd year so as to avoid the possible carry-over effects from previous spray.

Foliar Spray of Ca, Zn and B

The treatments consisted of foliar spray of different chemicals i.e., Ca, Zn and B at three levels of concentration (0.0, 0.4 and 0.8%). The solution of these chemicals was made ten litre each using calcium nitrate, zinc sulphate and borax 210.53, 121.21 and 353.64 g for 0.4% and 421.05, 242.42 and 527.27 g for 0.8%, respectively in water and the pH was adjusted to 7.0 by slaked lime [$Ca(OH)_2$] prior to making its desired volume. The amount of borax was dissolved in warm water as it does not soluble in water at normal temperature. Each tree was sprayed with aqueous solution of chemicals one month before fruit harvest using a power operated sprayer. The wetting agent Tween-20 (1.0ml per litre) of solution was used in all spray solutions as a surfactant for their better absorption.

Determination of respiration rate and biochemical changes

Twenty fruits in each treatment and each replication apparently of the same size and of similar physiological maturity were harvested randomly and packed in the CFB boxes and brought to laboratory of Department of Horticulture, Janta College, Bakewar, Etawah for physico-chemical analysis and storage. Mango fruits were kept in the standard size CFB boxes (31.5×22.0×25 cm) and stored at ambient temperature (average temperature, 33.2^{o}C and R.H. 66.3% in 2006 and 33.7^{o}C and 65.4% R.H. in 2007). Respiration rate of fruits (CO_2 evolution) was determined by the gas flow method to the procedure of Loomis and Shull (1937). β-carotene was estimated by adopting the method of Jenson (1970). Tannins, pectin and starch were estimated by volumetric method of as described by Ranganna (1986).

Statistical Analysis

Data recorded for two years were pooled to reach it more precise conclusions. Data under values in per cent were analysed on angular transformed values. The results have been interpreted on the basis of 'F' test and C.D. at 5% level of significance.

RESULTS

Fruit Respiration rate as influenced by Ca, Zn and B

From the data a typical trend of respiratory activity was noticed at the peak between 3 and 6 days of storage (Figure. 1). At the time of harvesting respiration rate was maximum (47.04 mg CO_2/kg/h) in untreated fruits (T_1). From pooled data of both years it is also evident that pre-harvest spray of Ca, Zn and B considerably reduced the rate of respiration. The lowest respiration rate (32.21 mg CO_2/kg/h) was recorded in fruits treated with Ca 0.8%+Zn 0.4%+B 0.4% (T_{23}), but it was statistically at par with T_{17} (33.25 mg CO_2/kg/h), T_{18} (32.61 CO_2/kg/h) and T_{26} (33.00 mg CO2/kg/h). The highest respiration rate was noted in untreated fruits.

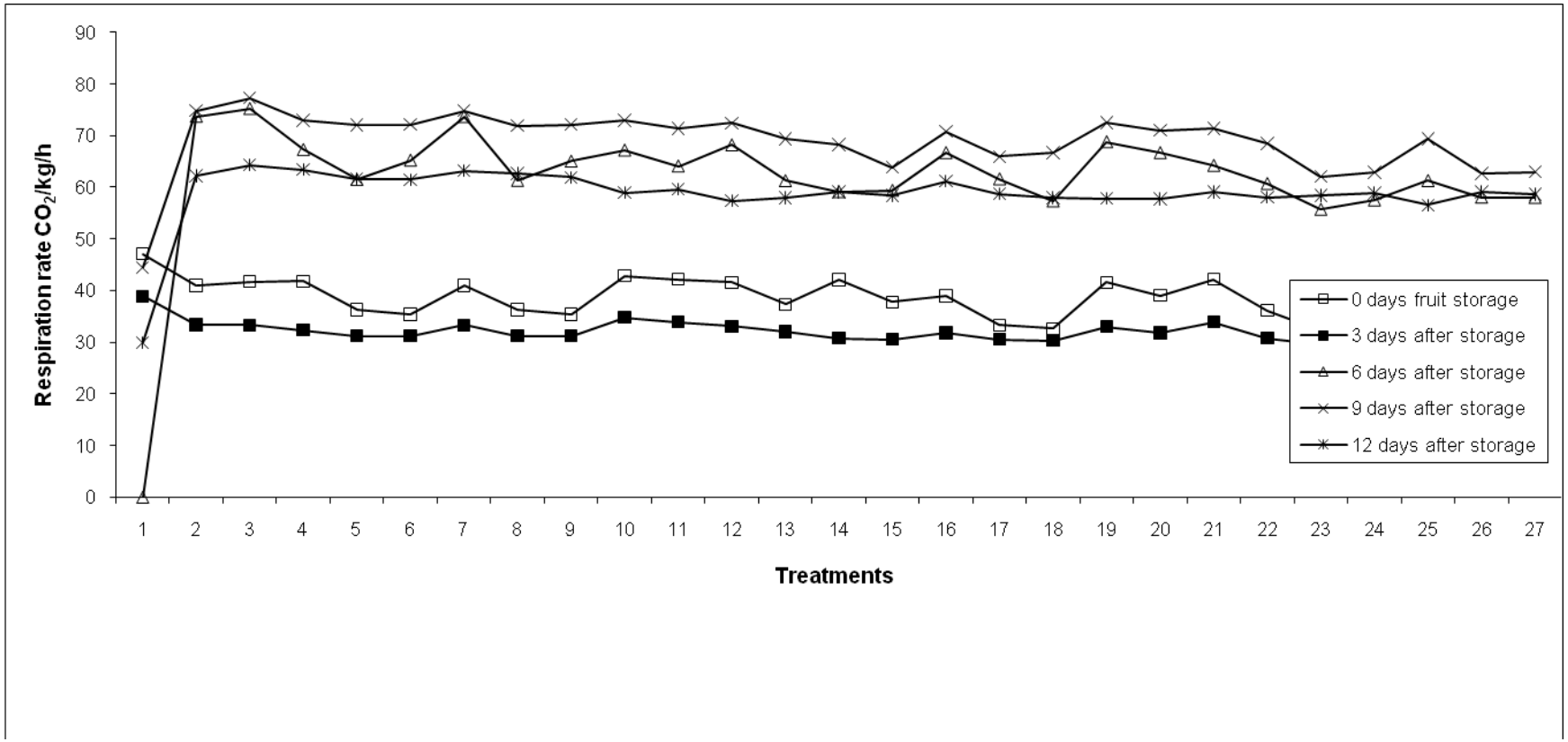

Figure 1. Effect of pre-harvest spray of Ca, Zn and B on respiration rate (mg CO_2/Kg/h) of mango fruits cv. Dashehari during storage.

T_1 Ca 0.0 + Zn 0.0 + B 0.0, T_2 Ca 0.0 + Zn 0.0 + B 0.4, T_3 Ca 0.0 + Zn 0.0 + B 0.8, T_4 Ca 0.0 + Zn 0.4 + B 0.0, T_5 Ca 0.0 + Zn 0.4 + B 0.4, T_6 Ca 0.0 + Zn 0.4 + B 0.8, T_7 Ca 0.0 + Zn 0.8 + B 0.0, T_8 Ca 0.0 + Zn 0.8 + B 0.4, T_9 Ca 0.0 + Zn 0.8 + B 0.8, T_{10} Ca 0.4 + Zn 0.0 + B 0.0, T_{11} Ca 0.4 + Zn 0.0 + B 0.4, T_{12} Ca 0.4 + Zn 0.0 + B 0.8, T_{13} Ca 0.4 + Zn 0.4 + B 0.0, T_{14} Ca 0.4 + Zn 0.4 + B 0.4, T_{15} Ca 0.4 + Zn 0.4 + B 0.8, T_{16} Ca 0.4 + Zn 0.8 + B 0.0, $T_{17,}$ Ca 0.4 + Zn 0.8 + B 0.4, T_{18} Ca 0.4 + Zn 0.8 + B 0.8, T_{19} Ca 0.8 + Zn 0.0 + B 0.0, T_{20} Ca 0.8 + Zn 0.0 + B 0.4, T_{21} Ca 0.8 + Zn 0.0 + B 0.8, T_{22} Ca 0.8 + Zn 0.4 + B 0.0, T_{23} Ca 0.8 + Zn 0.4 + B 0.4, T_{24} Ca 0.8 + Zn 0.4 + B 0.8, T_{25} Ca 0.8 + Zn 0.8 + B 0.0, T_{26} Ca 0.8 + Zn 0.8 + B 0.4, T_{27} Ca 0.8 + Zn 0.8 + B 0.8

In the first spell of storage, i.e., up to 3 days it was significantly decreased as it is evident that at the time of harvesting untreated releasing 47.04 mg CO_2/kg/h, which decreased to a level of 38.94 mg CO_2/kg/h after 3 days. It was at the peak between 3 and 6 days of storage as it rose to 75.55 mg CO_2/kg/h and again it decreased to a level 44.61 mg CO_2/kg/h after 9 days and it was minimum 30.06 mg CO_2/kg/h after 12 days. After 3 days of storage minimum respiration rate was noted in fruits treated with Ca 0.8%+Zn 0.4%+B 0.4% (T_{23}) in which it was 29.65 mg CO_2/kg/h, which was significantly lower as compared to T_1 (38.94 mg CO_2/kg/h), T_3 (33.30 mg CO_2/kg/h), T_7 (33.35 mg CO_2/kg/h), T_{10} (34.80 mg CO_2/kg/h), T_{11} (33.91 mg CO_2/kg/h), T_{12} (33.09 mg CO_2/kg/h), T_{19} (33.05 mg CO_2/kg/h) and T_{21} (33.96 mg CO_2/kg/h). The respiration rate after 6 days of storage was highest in untreated fruits

Table 1. TSS and total carotenoids contents in the fruits as influenced by Ca, Zn and B.

Treatments	TSS (^{o}Brix)					Total Carotenoids				
	Days after storage					Days after storage				
	0	3	6	9	12	0	3	6	9	12
T_1	8.06	9.88	16.05	18.29	17.59	0.284	1.236	3.339	3.557	3.536
T_2	8.44	10.90	17.41	21.07	19.88	0.312	1.285	4.991	5.045	4.927
T_3	8.37	10.52	17.16	20.40	19.16	0.311	1.277	4.985	5.035	4.903
T_4	8.40	10.56	17.51	20.85	19.29	0.310	1.295	4.970	5.027	4.887
T_5	8.50	10.92	17.54	20.78	19.96	0.313	1.312	5.010	5.062	4.948
T_6	8.41	10.42	17.48	21.31	20.15	0.312	1.301	5.006	5.062	4.928
T_7	8.82	11.00	17.16	20.40	19.11	0.310	1.291	4.975	5.031	4.899
T_8	8.50	10.95	17.61	20.71	19.94	0.312	1.312	5.006	5.059	4.934
T_9	8.47	10.40	17.50	21.27	19.68	0.312	1.292	5.008	5.059	4.926
T_{10}	8.37	10.42	17.31	21.14	19.29	0.312	1.280	4.997	5.047	4.925
T_{11}	9.36	11.04	18.35	21.29	20.41	0.314	1.299	5.021	5.057	4.956
T_{12}	8.45	11.21	17.48	20.88	19.47	0.314	1.299	5.021	5.062	4.950
T_{13}	9.02	10.66	18.36	21.53	20.37	0.313	1.298	5.020	5.066	4.946
T_{14}	8.57	10.45	18.11	21.58	20.50	0.316	1.336	5.039	5.087	5.007
T_{15}	8.74	11.10	17.80	21.01	20.05	0.315	1.332	5.039	5.085	5.002
T_{16}	8.72	10.71	17.84	21.23	19.76	0.314	1.296	5.019	5.068	4.950
T_{17}	8.74	10.68	18.97	21.61	20.63	0.315	1.328	5.033	5.068	4.994
T_{18}	8.55	10.43	17.93	21.56	20.67	0.315	1.329	4.991	5.075	4.991
T_{19}	8.38	10.71	17.34	20.80	19.41	0.312	1.280	4.998	5.053	4.926
T_{20}	8.70	10.60	17.78	21.20	19.72	0.314	1.325	5.027	5.073	4.989
T_{21}	9.33	10.98	18.31	21.47	20.30	0.314	1.300	5.021	5.065	4.963
T_{22}	8.63	10.72	18.53	21.32	20.74	0.314	1.304	5.021	5.070	4.979
T_{23}	9.51	11.32	19.42	22.39	21.92	0.320	1.392	5.076	5.105	5.079
T_{24}	9.43	10.84	19.16	21.96	21.34	0.317	1.359	5.047	5.099	5.015
T_{25}	9.06	10.77	18.41	21.58	20.46	0.315	1.303	5.031	5.067	4.983
T_{26}	9.47	11.09	18.43	22.10	21.62	0.318	1.370	5.061	5.102	5.026
T_{27}	9.13	10.89	18.30	21.87	21.28	0.316	1.348	5.044	5.093	5.008
Mean	**8.74**	**10.74**	**17.90**	**21.17**	**20.10**	**0.313**	**1.310**	**4.955**	**5.010**	**4.910**

(75.55 mg CO_2/kg/h) which was statistically at par with fruits treated with Ca 0.0%+ Zn 0.0%+B 0.4% (T_2) and Ca 0.0%+ Zn 0.0%+B 0.8% (T_3) and Ca 0.0%+ Zn 0.8%+B 0.0% (T_7). In general it is noted that combined sprays reduced the rate of respiration considerably. After 6 days it gradually decreased in untreated lots as it came to 44.61 mg CO_2/kg/h from 75.55 mg CO2/kg/h. However, after 9 days minimum rate of respiration (44.61 mg CO_2/kg/h) was recorded in untreated fruits T_1 (Ca 0.0%+ Zn 0.0%+B 0.0%). Among treated fruits, the minimum (62.10 mg CO2/kg/h) rate of respiration was recorded in fruits treated with Ca 0.8%+Zn 0.4%+B 0.4% (T_{23}). The respiration rate after 12 days of storage was minimum in untreated fruits (30.06 mg CO_2/kg/h), which was significantly lower as compared to remaining other treatments, in which it ranged between 56.54 and 64.22 mg CO_2/kg/h. Among treated fruits lowest rate was recorded in T_{25} (56.54 mg CO_2/kg/h) though it was statistically at par with other treated fruits.

Effect of Ca, Zn and B on biochemical properties of mango fruit during storage

Total soluble solids

Data reveal (Table 1) that TSS increased consistently as process of ripening proceeded with advancement of storage period regardless of the treatments up to 9 days and it declined a little thereafter on prolongation of storage in both the years of study under all the treatments including control. In the beginning of the experiment maximum TSS content of fruit pulp was recorded with T_{23} (9.51^{0}brix). After 3 days storage slight

Table 2. Starch content as influenced by Ca, Zn and B at different storage period.

Treatments	Starch (%)				
	Days after harvest				
	0	3	6	9	12
T_1	11.73	9.60	2.36	0.15	0.02
T_2	12.00	11.56	3.08	0.28	0.05
T_3	12.02	11.48	2.99	0.26	0.05
T_4	12.97	12.50	3.68	0.30	0.05
T_5	12.42	12.13	3.80	0.37	0.07
T_6	12.82	12.25	3.86	0.35	0.07
T_7	12.02	11.59	3.11	0.30	0.05
T_8	12.40	12.03	4.34	0.39	0.07
T_9	12.45	12.14	3.83	0.39	0.07
T_{10}	13.01	12.54	3.70	0.32	0.07
T_{11}	12.47	12.13	4.43	0.42	0.07
T_{12}	12.42	12.05	4.36	0.39	0.07
T_{13}	12.97	12.12	4.78	0.55	0.07
T_{14}	13.12	12.37	4.66	0.58	0.08
T_{15}	13.06	12.08	4.97	0.57	0.08
T_{16}	12.72	12.12	4.23	0.53	0.07
T_{17}	13.46	12.67	5.16	0.62	0.09
T_{18}	14.06	12.90	4.95	0.59	0.09
T_{19}	13.25	12.48	3.85	0.35	0.07
T_{20}	12.67	12.00	4.20	0.50	0.07
T_{21}	12.49	12.13	4.44	0.44	0.07
T_{22}	12.90	12.29	4.63	0.57	0.08
T_{23}	14.47	13.82	5.85	0.69	0.09
T_{24}	14.02	13.13	5.41	0.66	0.09
T_{25}	12.99	12.14	4.81	0.57	0.08
T_{26}	14.25	13.39	5.61	0.66	0.09
T_{27}	13.91	12.91	5.33	0.63	0.09
Mean	**12.93**	**12.24**	**4.31**	**0.46**	**0.07**

increase in level of TSS content was noticed under all treatments thereafter, considerable increase in TSS content was recorded between 3 and 6 days of storage under all treatments including control. After 3 days highest TSS were seen in fruits treated with T23 (11.32^0brix), which was significantly higher as compared to untreated fruits (9.88^0brix). T_{23} treatment showed a significant difference in TSS contents and proved its superiority over other treatments at all the stages of storage. After 6 days of storage the rise in TSS content was significant as average of all treatments was 17.90^0brix as compared to 10.74^0brix reported after 3 days storage. However, the content of TSS with T23 was at par after 6 days of storage with T_{24} (19.16^0brix) and T_{22} (18.53^0brix), after 9 days of storage with T_{14}, T_{17}, T_{18}, T_{21}, T_{24}, T_{25}, T_{26} and T_{27} and after 12 day of harvesting/ storage with T_{26}.

Total Carotenoids

The data given in Table 1 indicate that *Carotenoids* contents increased with the days of storage as pooled average of both years (2006 and 2007) at 0 day was only 0.313 mg/100 g pulp, which rose to 5.010 mg/100 g pulp after 9 days storage but after 12 days this declined to 4.910 mg/100g pulp. After 3 days of storage the *Carotenoids* ranged between 1.236 mg and 1.392 mg/100 g

pulp showing more or less same as there was no critical difference among various treatments. The significant differences were observed among treatments after 6 days of storage. The untreated fruits have shown 3.339 mg *Carotenoids* per 100g of pulp at an average which was significantly lower as compared to other treated lots. The highest carotenoids was recorded with T_{23} i.e. 5.076, 5.105 and 5.079 mg/100g after 6, 9 and 12 days of storage, respectively.

Starch

From data it is evident that starch content was quite high at the time of harvesting, which declined sharply during storage (Table 2). However this decline was slow up to 3 days and thereafter it was very rapid. The average of all treatments was 12.93 % at the time of harvesting, which came down to 12.24% after 3 days, 4.28 % after 6 days, 0.46 % after 9 days and finally 0.07 % after 12 days of storage.

It is quite clear that pre-harvest sprays of Ca, Zn, and B significantly affected the starch contents at the time of harvesting. The maximum starch content was recorded in T_{23} (14.97%) which was significantly higher as compared to other treatments except T_{26} (14.25%), T_{18} (14.06 %) and T_{24} (14.02 %). After storage of 0, 3, 6, 9 and 12 days untreated fruits showed 11.73, 9.60, 2.36, 0.15 and 0.02% starch content, respectively. Simultaneously, starch content among treated fruits was ranged from 12-14.47, 11.48-13.82, 2.99-5.85, 0.26-0.69 and 0.05-0.09%, respectively. However, treatment T_{23} consistently showed its efficacy in maintaining higher starch content over other treatments during the experimentation.

Tannins

The data (Table 3) clearly indicate that just after harvesting tannin contents gradually declined in all the samples with the advent of storage period and every time this decrease was statistically significant. It is seen that at the time of harvesting the average of all treatments was 0.154 %, which declined to 0.138% after 3 days and to 0.107 % after 6 days of storage. After 9 days a rapid decline was noted and this average came to 0.047 % and after 12 days of storage this average became as low as 0.028%.

None of the treatments showed significant effect on the tannin contents of fruits of freshly harvested and at 3 days storage. The effect of treatments was only visible after 6 days of storages. However, the tannins in fruits was maximum wtihT_{23} treatment (Ca 0.8% + Zn 0.4% .+ B 0.4 %) at all the stages of storage.

Pectin

From the data it is evident content that pre-harvest sprays of Ca, Zn, and B significantly affected the pectin content of fruits (Table 3). The date revealed that pectin content of all sample decreased with the advent of storage period as at the time of harvesting the average of pectin of all samples was 0.486 %, which finally come down 0.078 % after 12 days storage.

Among the freshly harvested fruits minimum pectin content was observed in untreated samples (0.440 %) and maximum pectin content was recorded with T_{23} (0.540%) followed by T_{26} (0.536%), T_{22} (0.523%) and T_{24} (0.513 %). After 3 days of storage minimum pectin was recorded in untreated fruits (0.268%), which was significantly lower as compared to other treated lots except T_2 (0.283 %). At this stage T_{27} demonstrated maximum pectin content (0.478%), which was significantly higher as compared to other treatments except T_{26} (0.437%) and T_{24} (0.430%), which were statistically at par with it. At 6 and 9 days storage maximum pectin was observed with T_{23} being 0.363 and 0.264%, respectively. Although, the pectin content was dropped considerably after 12 days of storage among all treated and untreated fruits yet fruits treated with T23 treatment showed steadily decline in the pectin content.

DISCUSSION

The most important postharvest need is the retention of physico-chemical quality as well as enhanced shelf life of fruits, so that excellent quality fruits can be marketed for good price for extended period. Several manipulations are possible so as to provide best nutrition to trees to produce quality fruits of mango. There is a great role of pre-harvest cultural techniques, to increase the shelf life of fruits. Out of such cultural techniques one is to apply of plant nutrients like Ca, Zn and B as pre harvest foliar spray during the period of fruit growth. As results apparently demonstrate that respiratory activity was higher in freshly harvested fruits, after that a slight fall was recorded at the commencement of storage at about 3 days under all treatments including control. It is a fact that respiration decreases as the fruit mature and then the respiratory rise commences with ripening. Ethylene production also decreases as fruit matures (Akamine and Goo, 1973).

The rise in climacteric onset occurred in between 3 and 6 days of storage, in all treatments, whereas in this period, control fruits showed achievement in climacteric peak with steep fall, at this stage due to previous high respiration rate the quantity of material available for further respiration decreased considerably. While in the treated fruits climacteric peak occurred at 9th day of storage. It is established fact that climacteric peak in fruits, occur due to higher ethylene evolution. Mattoo and Modi (1969) suggested that together with the ethylene evolution and respiration climacteric in mangoes, the catalase and peroxidase activity was found to increase considerably during ripening. Thus, calcium treated fruits

Table 3. Effect of preharvest application of Ca, Zn and B on Tannin and pectin content in mango fruit.

Treatments	Tannin (%)					Pectin (%)				
	Days after harvest					Days after harvest				
	0	3	6	9	12	0	3	6	9	12
T_1	0.144	0.124	0.066	0.027	0.020	0.440	0.268	0.107	0.049	0.019
T_2	0.148	0.133	0.088	0.029	0.023	0.453	0.283	0.169	0.085	0.044
T_3	0.150	0.131	0.092	0.029	0.022	0.444	0.286	0.172	0.078	0.042
T_4	0.142	0.121	0.101	0.030	0.023	0.475	0.293	0.178	0.095	0.047
T_5	0.163	0.132	0.106	0.045	0.025	0.463	0.338	0.213	0.118	0.067
T_6	0.151	0.137	0.110	0.041	0.023	0.450	0.293	0.157	0.092	0.052
T_7	0.150	0.134	0.094	0.030	0.023	0.449	0.286	0.169	0.092	0.048
T_8	0.162	0.133	0.110	0.047	0.026	0.456	0.345	0.198	0.115	0.066
T_9	0.152	0.141	0.113	0.043	0.023	0.463	0.343	0.205	0.120	0.065
T_{10}	0.147	0.126	0.104	0.032	0.024	0.473	0.355	0.240	0.125	0.068
T_{11}	0.152	0.145	0.108	0.046	0.027	0.482	0.363	0.250	0.128	0.070
T_{12}	0.150	0.134	0.100	0.039	0.026	0.513	0.361	0.235	0.125	0.068
T_{13}	0.155	0.144	0.117	0.051	0.028	0.511	0.363	0.243	0.134	0.078
T_{14}	0.154	0.139	0.120	0.061	0.032	0.497	0.409	0.289	0.162	0.098
T_{15}	0.160	0.133	0.110	0.055	0.031	0.513	0.416	0.314	0.204	0.096
T_{16}	0.154	0.141	0.117	0.051	0.027	0.486	0.415	0.235	0.135	0.078
T_{17}	0.151	0.139	0.120	0.061	0.036	0.506	0.412	0.315	0.193	0.102
T_{18}	0.166	0.141	0.110	0.058	0.034	0.492	0.437	0.256	0.165	0.099
T_{19}	0.151	0.132	0.100	0.038	0.026	0.478	0.358	0.241	0.124	0.070
T_{20}	0.153	0.139	0.115	0.048	0.026	0.487	0.415	0.230	0.133	0.078
T_{21}	0.152	0.143	0.108	0.043	0.025	0.482	0.364	0.248	0.125	0.072
T_{22}	0.164	0.134	0.118	0.053	0.033	0.523	0.367	0.244	0.124	0.088
T_{23}	0.170	0.153	0.124	0.064	0.040	0.540	0.478	0.363	0.264	0.138
T_{24}	0.155	0.152	0.116	0.062	0.037	0.513	0.430	0.331	0.219	0.127
T_{25}	0.156	0.149	0.112	0.052	0.032	0.511	0.363	0.228	0.137	0.082
T_{26}	0.155	0.151	0.117	0.067	0.034	0.538	0.437	0.356	0.219	0.127
T_{27}	0.163	0.141	0.114	0.060	0.033	0.495	0.450	0.297	0.207	0.117
Mean	**0.154**	**0.138**	**0.107**	**0.047**	**0.028**	**0.486**	**0.367**	**0.240**	**0.139**	**0.078**

might have delayed rise in catalase and peroxidase activities as compared to control. The decrease in rate of respiration after 9th and 12th day in control and treated fruits, respectively, may be due to depletion of acids during respiratory processes (Cheema and Dani, 1934).

However in all the treated fruits significant reduction in respiration rate was recorded as compared to control. The reduced respiration rate was noted with T23 (Ca 0.8%+Zn 0.4%+B 0.4%). It might be due to presence of higher concentration of calcium, which is the constituent of cell wall, slows the process of respiration and over ripening and zinc regulates the semi permeability of cell walls, which slows the processes of respiration thereby delay the senescence. Treated fruits did not develop an ethylene rise because of inhibition of autocatalytic production of ethylene in fruits. Jones and Lunt (1967) and Bain and Mercer (1963) reported that in calcium controlled the disintegration of mitochondria, endoplasmic reticulum and cytoplasmic membrane and thus, it helped in retarding the rate of respiration. The results of present experiment therefore are in agreement with the earlier findings recorded in mango (Wavhal and Athale, 1988) and apricot (Sud and Bhutani, 1989).

During storage TSS of fruits varied significantly with different treatments. The increase in TSS was noted up to 9 days of storage under all treatments applications. However, higher TSS was recorded in treated fruits as compared to control. The increase in TSS with the advance-

ment of storage period may be assigned to hydrolysis of starch content of the fruits in the presence of enzymes, viz., α -amylase, β -amylase and starch phosphorelase, resulting in general increase in TSS (Salisbury and Ross,1974). The conversion of cell wall materials such as pectin and hemi cellulose into simple soluble sugars during storage may also be responsible for the increase TSS content. After 9 days storage total soluble solids sharply declined. The decline in TSS at later stages might be due to the utilization of carbohydrate and possibly oxidation of fat and proteins as the respiratory substrates as suggested by Bhullar et al., 1983.

The maximum TSS was noted in the fruits treated with combined spray of Ca (0.8%), Zn (0.4%) and B (0.4%). This may probably be due to the increased metabolism of sugars mediated by boron from the source (Sisler et al., 1956). Analogous observations to these findings were also reported by earlier workers in mango (Rath et al*.,* 1980; Daulta et al*.,* 1981; Banik et al., 1997, Bhatt et al., 2012), guava (Jayachandran et al*.,* 2005) and banana (Kumar and Brahmachari, 2006; Jeyabaskaran and Pandey, 2008).

The pulp *Carotenoids* level increased in all the treatments with advancement of storage. Higher level of *Carotenoids* was noticed up to 9th day of storage under all treatments and fruits turned green to yellow and yellow-orange by this day. However, the total carotenoids increased up to 9th day and later on they decreased. Fruits treated with calcium, zinc and boron showed higher carotenoids as compared to control. These treatments increased the permeability of external tissue and activated the enzymatic activities, which are responsible for carotene synthesis, hence it hastened the ripening and development of colour. The results was in agreement with the finding of Subramanyam and Sebastian (1970), Wavhal and Athale (1988) and Krishnamurthy (1989) in mango. On contrary, Haribabu and Krishamurthy (1993) in Alphonso mango and Ramkrishna et al. (2001) in papaya reported that the rate of increase in total carotenoids was more in the control fruits as compared to fruits sprayed with higher concentration of calcium chloride and calcium nitrate.

Findings of present investigation indicate that tannin contents decreased gradually as the storage advanced. In the present experiment, it seems that oxidase activity after being more or less constant for an earlier part of storage, it slightly increased or remained constant towards the subsequent period of storage. Similarly, tannin content decreased towards the end of storage. Thus, fall in tannin during storage may be partly attributed to the general increase in oxidase activity noticed in present case. Tannins are water soluble phenolics found in peel and pulp of fruits. Ripening polymerizes the tannins resulting in a loss of astringency. In the present case treated fruits showed higher tannin content as compared to control may be slow processes of ripening as influenced by calcium, zinc and boron.

The higher percentage of starch was recorded in mango fruits at the time of harvesting and thereafter there was a gradual fall in starch content up to 9 days storage. After 12 days of storage nearly total starch was hydrolyzed and negligible quantity remained. This finding corroborate with Biale (1960), who also reported almost complete hydrolysis of starch in the mango fruits during ripening. In earlier stage, approximately equal concentration of glucose and fructose, together with a little sucrose appear. After prolonged storage, level of all three sugars decreased. The mango, on the other hand, showed a large increase in sucrose concentration and a smaller proportion of reducing sugars as starch is hydrolyzed. Later in storage, sucrose tends to disappear and is replaced by an equal amount of reducing sugars. Such losses of starch, in the present study could possibly be attributed to activation of hydrolytic enzymes resulted in increased conversion of starch into sugars. A higher accumulation of starch in treated fruits as compared to control up to 9 days storage was seen, probably Ca, Zn and B application might have brought about certain changes in metabolism of fruits reflecting in more accumulation of food constituents in the developing fruits and thus, ultimately resulted comparatively higher content of starch than control.

Results of present experiment depict that pectin content of fruit pulp decreased with corresponding increase in storage period. The fall in total pectin during storage was observed to be associated with the occurrence of slight mealiness in the fruit, presumably through the degradation of polygalacturonic acid chains since, the viscosity of extracted pectin was found to decrease in fruits (Eggenberger, 1949; Mc Cready and Mc Comb, 1954). The PME activity remained low on fruits treated with Ca, Zn and B. PME is responsible for the de-esterification of pectin required before PG starts the depolymerization of pectins associated with fruit softening (Mc Cready et al., 1955). Higher values of pectin content were recorded with the foliar nutrition of calcium, zinc and boron. This may be due to fact that these nutrients retarded process of softening which resulted in corresponding retardation of both polygalacturonase (PG) and galactosidase activities (Lazon and Ali, 1993). Such losses of sugars could possibly be attributed to hydrolysis of galactanes and arabino galactans by galactosidase having galactonase activity, tissue softness and increased pectin solubility and degradation suggest that β-galactocidase might play an important role in the cell wall pectin modification and softening of mango fruits during ripening (Ali et al., 1995). Several other workers Singh and Chauhan (1981) and Jayachandran, (2005) also recorded higher pectin content and lower PME activity application with calcium in guava fruits.

An improvement in quality of the fruit was also recorded with pre harvest spray of Ca 0.8% + Zn 0.4% + B 0.4% application as evident by higher TSS, sugar, sugar: acid blend, total *Carotenoids*, pectin and better organoleptic

rating ,i.e., texture, colour, flavour and taste), which is desirable for quality fruit, during both the years of study. Thus, minimizing post-harvest losses and increasing consumer's acceptability by maintaining the different quality parameters for long time during storage provided the great market potential for the "Dashehari" fruits. It may further be concluded that Ca 0.8% + Zn 0.4% + B 0.4% is most suitable combination for pre-harvest foliar spray on 'Dashehari' mango to achieve of more uniform ripening, better quality and improved post harvest shelf life under subtropical condition.

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