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Effect of Pre-harvest Nutrients Application and Bagging on Quality and Shelf Life of Mango (*Mangifera indica* L.) Fruits *cv*. Amrapali

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ABSTRACT

The present experiment was conducted to study the effect of pre-harvest bagging and spray of $CaCl_2$ and K_2SO_4 on quality and shelf life of mango fruits *cv*. Amrapali during two succeeding years. Trees of Amrapali mango were sprayed three times at 30, 20, and10 days before harvesting and bagging with brown paper bag 20 days before harvesting of fruits. Harvested fruits were stored under the ambient temperature (storage at room temperature) and observations were taken at three days intervals upto 18 days. The results indicated that the pre-harvest treatment of 2% $CaCl_2$+1% K_2SO_4+bagging was found superior to improve the quality of fruits in respect of highest fruits weight, firmness, TSS, ascorbic acid, total sugars, and *β*-carotene content with minimum black spotted fruits per cent and maintained it throughout the storage period upto 18 days. Fruits treated with 2% $CaCl_2$+1% K_2SO_4+bagging showed shelf life up to 12 days with lowest weight loss and highest organoleptic quality as against 6 days of untreated fruits (control).

Keywords: Black spotting, $CaCl_2$, K_2SO_4, Pre-harvest treatments, Storage.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruits of India and acknowledged as the "king of fruits". It belongs to the family Anacardiaceae and genus Mangifera. Mango is recognized as one of the choicest and well accepted fruits all over the world due to its luscious taste, captivating flavor, attractive color and exemplary nutritive value. It plays an important role in balancing the human diet by providing about 64-86 calories per 100 grams of ripe fruits (Rathore *et al.,* 2007). It is a good source of vital protective nutrients like vitamins A, B, and C, niacin, and also rich in minerals including calcium, potassium and iron (Amin and Hanif, 2002). Mango fruit is utilized at both immature and mature stages. Raw fruits are used for making chutney, amchur, pickles, and juices. The ripe fruits are also utilized for processing of several products like ready-to-serve, nectar, squash, panna, syrup, mongo leather, mango powder, flakes, toffee, jams, and jelly.

India has a rich wealth of mango germplasm with more than 1,000 varieties grown throughout the country (Yadav, 1997). Only a few varieties *viz.* Alphanso and Kesarare are available with better storage life, and hence better suited for export. But, production of these cultivars is very limited. Among the promising mango hybrids, Amrapali is a well known late maturing and regular bearer dwarf hybrid variety. It was evolved as a result of a cross between 'Dasheheri (alternate bearer) and Neelum (regular bearer)' varieties of mango species *Indica* at IARI, New Delhi, in 1978.

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Amrapali possesses quality par excellence with very high pulp percentage and TSS with deep orange red flesh color and excellent in taste. Amrapali is one of the best suitable varieties for inter as well as overseas markets and processing industries.

Being a climacteric fruits, it is perishable in nature and possesses a shorter shelf life about one week at ambient temperature. After harvest, various physiological and biochemical changes occur in fruits which cause decline in quality and limit its shelf life. Amrapaliis is also susceptible to post harvest diseases due to its harvesting in rainy season, resulting in excess post harvest losses. Anthracnose (*Coletotrichum gloeosporioides*) and stem-end rot (*Diplododia netalensis*) are the major post harvest diseases of mango fruits, which cause black spots on fruits skin during ripening and storage. Many scientists estimated that 20-30 per cent losses in fruits and vegetables are due to post harvest diseases (Yadav *et al.,* 2013). The main bottlenecks associated with this variety are its shorter shelf life and post harvest losses mainly due to post harvest diseases. In mango, post harvest losses lie in the range of 25-40% from harvesting to consumption stage (Tahir *et al.*, 2002) and reduction in these losses is essential for increase the availability of fruits. However, loss of this very perishable commodity is a big worth annually.It is not only a serious problem of Amrapali growers and traders in India, but present time improvement in the shelf life and reduction in the post harvest losses of mango fruit is an international issue. Hence, this investigation was formulated with pre-harvest nutrient application and fruits bagging.

Pre-harvest paper bagging is a physical protection method which not only improves the visual quality of fruit by promoting skin coloration and reducing blemishes, but can also change the micro-environment for fruit development, which can have several beneficial effects on internal fruit quality. Pre-harvest bagging of fruit can also reduce the incidence of disease, insect pest and/or mechanical damage, sunburn of the skin, fruit cracking, agrochemical residues on the fruit, and bird damage (Sharma *et al*., 2014). The pre-harvest spray of $CaCl_2$ reduces the weight loss, delays the ripening of fruits, increases the shelf life, physico-chemical parameters, and organoleptic quality of mango fruits (Karemera and Habimana, 2014). Madani *et al.* (2014) reported that the pre harvest preharvest application of 2% calcium chloride improves the quality and decreases the enzymatic activity in papaya fruits during the storage. Treatment with calcium nitrate and calcium chloride (0.6-2.0%) delayed ripening after harvest, lowered weight loss, and reduced respiration rates (Bender, 1998). It enhances the mango quality by increasing the fruit firmness and by maintaining the middle lamella cells. Fruits storability was also improved by $CaCl_2$ under cold storage (Wahdan *et al*., 2011). The potassium treatments improve the productivity of several mango cultivars in terms of fruit size and weight. Pre-harvest treatment of 1% potassium sulfate have resulted in improving the fruit quality parameters i.e. juice content, total soluble solids, ascorbic acid, total sugars, and reducing the weight loss during the storage. Sulfate compound can also reduce the infection of diseases (Burondkar *et al*., 2009). The aim of the present study was to determine the effect of pre-harvest nutrient application and fruits bagging on post harvest quality and shelf life of mango fruits *cv*. Amrapali.

MATERIALS AND METHODS

Plant Material and Treatment

The experiment was conducted at Main Experimental Station, Horticulture and Post Harvest Technology Laboratory of ND University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh (India) during the two successive seasons of 2010-2011 and 2011-2012. Fourteen-year old bearing trees of mango *cv*. Amrapali, having

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uniform vigor and health were selected in high density mango orchard. Trees were spaced 2.5×2.5 m and received uniform pruning and cultural operations. Twenty-four selected trees were subjected to eight pre-harvest treatments *viz.* bagging(T_1), 2% $CaCl_2$ (T_2), 1% K_2SO_4 (T_3), 2% $CaCl_2$+bagging (T_4), 1% K_2SO_4+bagging (T_5), 2% $CaCl_2$+1% K_2SO_4 (T_6), 2% $CaCl_2$+1% K_2SO_4+bagging (T_7), and Control (T_8) with three replications. One tree was taken as a unit for a replication of treatment.

Treatments Methodology

Fruits were bagged at 20 days before harvesting of fruits using single layer brown paper (pulp paper) bags. Twenty five uniform sized fruits were marked at all directions of the canopy of the trees. Individual fruit was covered with brown paper bag and tied with thread on the stalk of fruits. Treatment with 2% $CaCl_2$ and 1% K_2SO_4 alone and their combination were sprayed three times at 30, 20, and 10 days before harvesting, whereas treatments along with bagging were sprayed only at 30 and 20 days before harvesting and just after second spray, treated fruits were bagged. Twin-20 was used as spreader in spray solution.

Fruit Harvest and Storage

Fruits of all trees were separately harvested at optimum maturity stage by hand with 1.0 cm stalk to escape any damage of fruit. Harvesting was done in the morning hours dated 14th July during both years. The field heat of harvested fruits was removed by dipping in fresh water and then carefully sorted and graded as fresh and uniform sized fruits. These fruits were transported from orchard to the laboratory without any type of physical damage including bruising. In the laboratory, fruits were washed in running tap water and cleaned with muslin cloth. Fruits were packed in corrugated fiber board boxes with the use of newspaper as liner. All boxes were tagged as per treatments and stored under ventilated room (at ambient temperature) for 18 days. Weather data during the trial from 14th June to 1st August (2010 and 2011) are given in Table 1.

Fruit Quality Analysis

Three fruits per treatment were evaluated for quality analysis just after harvesting and at 6 days intervals during storage until 18 days by the following methods.

Fruit Weight (g): Fruits were taken randomly and their weight was recorded with the help of physical balance. Average weight was calculated and expressed in gram.

Weight Loss (%): Weight of fruits was recorded with the help of physical balance and weight loss per cent was calculated by using the following standard procedure mentioned in AOAC (2000).

Fruit Firmness (kg cm^{-2})**:** Fruit firmness

Table 1. Weather data during the trial from 14th June to 1st August (2010 and 2011).

Month	Date	Temperature (°C)				Relative humidity (%)		Rainfall (mm)	
		2010		2011					
		Min	Max	Min	Max	2010	2011	2010	2011
July	14	27.0	33.0	28.0	35.0	86.8	78.6	0.0	0.0
	17	25.2	35.0	25.0	32.0	92.7	93.8	0.0	38.2
	20	25.5	30.0	27.5	29.0	97.8	92.9	14.5	0.0
	23	25.0	35.0	25.0	34.0	86.6	77.7	0.0	0.0
	26	27.0	30.0	27.0	34.0	73.7	83.6	3.2	0.0
	29	27.5	33.0	26.5	34.5	83.8	92.6	0.0	0.0
August	1	26.0	32.0	26.0	33.0	95.9	94.7	0.0	20.3

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$$\text{Weight loss \%} = \frac{\text{Initial fruit weight - Weght of fruit on observation day}}{\text{Initial fruit weight}} \times 100$$

was determined as reported by Magness and Taylor (1925), with the help of pressure tester by using a 5/16 plunger. Two readings were taken at two opposite sides on the fruit and mean was expressed in kg cm^{-2}.

Black Spotted Fruits (%): Black spotted fruits were collected and their weight was recorded with the help of physical balance. The per cent of black spotted fruits was calculated by using the following formulae:

$$\text{Black spotted fruits (\%)} = \frac{\text{Weight of Black spotted fruits on observation day + Weight of previous Black spotted fruis}}{\text{Initial fruits weight}} \times 100$$

Total Soluble Solids (TSS%): TSS were determined with the help of hand refractometer of 0-32 per cent range. The reading was corrected to $20^{\circ}C$ with the help of reference table (Ranganna, 1986) and the mean value was expressed as per cent total soluble solids in fruit pulp.

Acidity (%), Ascorbic Acid (mg 100 g^{-1}) and β-carotene (µg 100 g^{-1}): Acidity (%), ascorbic acid (mg 100 g^{-1}) and β-carotene (µg 100 g^{-1}) were determined by the procedures of Ranganna (1986).

Total Sugars (%): Total sugars content was determined by Fehling's solution method given by (Lane and Eynon, 1923).

Organoleptic Evaluation:

The organoleptic evaluation for assessing sensory attributes such as peel color, flesh color, texture, taste and flavor of the stored fruits were made by using 9 point Hedonic Rating Scale by a panel of eight judges as described by Larmond (1977).

Shelf Life

The shelf life (days) was determined upto the time when weight loss of fruits reached 10 percent during the storage. The shelf life of fruits was accounted from the date of harvesting to the shelf life expiration date.

Statistical Analysis

The data obtained in this study was subjected to Analysis Of Variance (ANOVA) for a Randomized Block Design (RBD) with three replications and the means were compared using OPSTAT of CCS HAU, Hisar, Haryana, India with $P< 0.05$ being accepted as significant.

RESULTS AND DISCUSSION

Fruits Weight (%)

The pre-harvest treatment of 2% $CaCl_2$+1% K_2SO_4+bagging was found superior to produced mango fruit of maximum weight (173.73 and 200.70g) which was statistically at par with the treatment of 2% $CaCl_2$+1% K_2SO_4 in both years, respectively (Table 2). However, minimum fruit weight was recorded in the control (120.35 and 143.39g) in both years, respectively. The appreciable improvement in fruit weight has also been earlier reported with the pre-harvest application of 1.5% $CaCl_2$ by Karemera and Habimana (2014) and 1% K_2SO_4 by Burondkar *et al*. (2009) in mango fruits. Chonhenchob *et al.* (2011) studied the effects of pre-harvest bagging on mango in Taiwan and reported that bagging increased fruit weight, size, and sphericity over un-bagged fruit.

The fruits weight gradual decrease with the advancement of storage period in both years might be due to evapo-transpiration of water, respiration, and degradation processes

Table 2. Effect of pre-harvest nutrient application and bagging on average fruit weight (g) of mango *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	144.78	137.74	127.41	117.61	131.89	172.16	164.48	152.20	140.43	157.32
2% $CaCl_2$	158.76	153.57	145.47	134.27	148.02	188.23	182.64	173.36	160.01	176.06
1% K_2SO_4	173.07	164.14	151.86	140.28	157.34	203.31	187.62	179.83	166.25	184.25
2%$CaCl_2$+Bagging	163.36	158.89	150.37	138.63	152.81	191.16	186.44	177.97	163.54	179.78
1%K_2SO_4+Bagging	174.85	166.54	153.72	142.45	159.39	204.14	196.34	181.74	169.43	187.91
2%$CaCl_2$+1% K_2SO_4	181.85	176.51	167.55	154.24	170.04	210.33	204.55	195.11	179.42	197.35
2%$CaCl_2$+1%K_2SO_4 +Bagging	184.53	179.89	172.30	158.20	173.73	213.20	207.69	199.30	182.60	200.70
Control	132.56	125.47	116.04	107.32	120.35	157.54	150.33	138.47	127.20	143.39
Mean	164.22	157.84	148.09	136.62	151.69	192.51	185.98	174.75	161.11	178.34

	Treatments (t)	Storage days (d)	t×d	Treatments (t)	Storage days (d)	t×d
SEm±	1.51	1.09	2.07	1.41	1.15	2.12
P< 0.05	4.53	3.19	5.82	4.24	3.33	5.94

occurring during the storage (Haard and Salunkhe, 1975). In this study, fruits treated with 2% $CaCl_2$+1% K_2SO_4+bagging showed the slower rate of decrease in fruits weight over all the treatments (Table 2). Similarly, the slower rate of decrease in fruit weight during the storage has also been reported with application of 1.5% $CaCl_2$ by Karemera and Habimana (2014) and fruit bagging by Chonhenchob *et al.* (2011) in mango fruits.

Weight Loss (%)

The weight loss per cent in mango fruits significantly increased with the advancement of storage period in both years of experiment. The lowest weight loss (7.94% and 7.57%) of fruits was recorded in the treatment of 2% $CaCl_2$+1% K_2SO_4+bagging, while maximum weight loss (12.88% and 12.55%) occurred in the control (Table 3). Whereas, treatment of 2% $CaCl_2$+bagging appeared to be the second best for minimizing the weight loss per cent in fruits during storage period. The decrease in weight loss by the application of calcium chloride may be due to its role in the maintenance of fruits firmness, reduction of respiration, and delay in the senescence (Cheor *et al*., 1990). Karemera and Habimana (2014) also reported that the mango fruits *cv*. Alphonso treated with 1.5% $CaCl_2$ spray showed the minimum weight loss during storage. The results are also in accordance with earlier reports of Burondkar *et al*. (2009) and Mathooko *et al*. (2011).

Fruit Firmness (kg cm^{-2})

The maximum firmness (7.15 and 7.07 kg cm^{-2}) was recorded in treatment of 2% $CaCl_2$+1% K_2SO_4+bagging, while the lowest fruit firmness (5.59 and 5.52 kg cm^{-2}) was noticed in the control in both years, respectively (Table 4). The fruit firmness of mango gradually decreased during the entire period of storage mainly due to the softening of cell wall during the ripening and senescence. Softening of fruits is caused either by breakdown of insoluble proto-pectin into soluble pectin or cellular disintegration leading to membrane permeability (Mootto *et al.,* 1975). Whereas, fruits treated with the treatment 2% $CaCl_2$+1% K_2SO_4+bagging showed slow reduction in firmness during the storage (Table 4). Similarly, Karemera and Habimana (2014) reported that the effect of pre-harvest spray of $CaCl_2$ on increasing the firmness of Totapuri mango fruits was due to its effect on maintaining the middle lamella cells. Sharma *et al.* (2013) have also

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Table 3. Effect of pre-harvest nutrient application and bagging on weight loss (%) in mango fruits *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days				2011-2012 Storage days			
	6	12	18	Mean	6	12	18	Mean
Bagging	4.86	12.73	18.95	12.18	4.45	12.18	18.31	11.65
2% $CaCl_2$	3.26	8.96	15.12	9.11	2.99	8.47	14.77	8.74
1% K_2SO_4	5.16	12.91	18.56	12.21	4.84	12.56	18.30	11.90
2%$CaCl_2$+Bagging	2.73	8.55	15.04	8.77	2.46	7.81	14.47	8.25
1%K_2SO_4+Bagging	4.75	12.58	18.23	11.85	4.37	11.99	17.95	11.43
2%$CaCl_2$+1% K_2SO_4	2.93	8.56	15.09	8.86	2.72	7.95	14.25	8.31
2%$CaCl_2$+1%K_2SO_4 +Bagging	2.51	7.23	14.07	7.94	2.13	6.85	13.73	7.57
Control	5.34	13.06	20.24	12.88	4.99	12.63	20.02	12.55
Mean	3.94	10.57	16.91	10.47	3.62	10.05	16.47	10.05
	Treatments (t)	Storage days (d)	t×d		Treatments (t)	Storage days (d)	t×d	
SEm±	0.13	0.06	0.30		0.13	0.07	0.30	
P< 0.05	0.38	0.18	0.87		0.39	0.17	0.87	

Table 4. Effect of pre-harvest nutrient application and bagging on firmness (kg cm^{-2}) of mango fruits *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	8.31	7.49	5.64	2.88	6.08	8.21	7.41	5.58	2.81	6.00
2% $CaCl_2$	8.76	8.24	6.45	3.57	6.75	8.58	8.07	6.38	3.50	6.63
1% K_2SO_4	7.98	7.23	5.31	2.55	5.77	7.90	7.16	5.25	2.49	5.70
2%$CaCl_2$+Bagging	8.93	8.39	6.62	3.77	6.93	8.87	8.32	6.55	3.70	6.86
1%K_2SO_4+Bagging	8.41	7.58	5.75	2.95	6.17	8.30	7.51	5.68	2.89	6.10
2%$CaCl_2$+1% K_2SO_4	8.84	8.36	6.60	3.65	6.86	8.77	8.30	6.53	3.62	6.81
2%$CaCl_2$+1%K_2SO_4 +Bagging	9.12	8.58	6.86	4.02	7.15	9.03	8.51	6.80	3.95	7.07
Control	7.71	6.99	5.22	2.44	5.59	7.62	6.91	5.16	2.38	5.52
Mean	8.51	7.86	6.06	3.23	6.41	8.41	7.77	5.99	3.17	6.34
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
***SEm*±**	0.03		0.04		0.11	0.03		0.05		0.13
P< 0.05	0.10		0.11		0.30	0.10		0.13		0.36

reported that the bagged 'Royal Delicious' apple fruit were firmer at harvest than un-bagged fruit, and that bagged fruit retained higher firmness values during storage.

Black Spotted Fruits (%)

The minimum black spotted fruit (4.46 and 7.35%) was recorded in treatment of 2% $CaCl_2$+1% K_2SO_4+bagging, whereas maximum (96.61 and 100%) was noted in the control in both years, respectively (Table 5). Also, treatment of 1% K_2SO_4+bagging, 2% $CaCl_2$+bagging, and bagging alone, respectively, were also found effective in minimizing the black spotted fruit per cent over the control. Black spotted fruit per cent significantly increased during the storage period in both years. Black spotting in stored mango is mainly due to the infection of anthracnose caused by *Coletotrichum gloeosporioides* and stem-end rot caused by *Diplododia netalensis* (Yadav *et al.,* 2013). Similarly, pre-harvest fruit bagging has been reported to reduce the incidence of anthracnose and stem-end rot in mango. It also improves the physical quality i.e., the

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Table 5. Effect of pre-harvest nutrient application and bagging on black spotted fruit (%) in mango *cv.* Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	2.65	2.65	15.55	26.40	11.81	3.23	3.23	18.76	28.03	13.31
2% $CaCl_2$	30.67	53.42	83.24	100	66.83	37.78	65.56	96.19	100	74.88
1% K_2SO_4	24.36	44.78	71.25	100	60.10	30.46	53.61	88.97	100	68.26
2%$CaCl_2$+Bagging	1.96	1.96	10.27	19.06	8.31	2.08	2.08	13.40	24.19	10.44
1%K_2SO_4+Bagging	1.25	1.25	8.50	18.26	7.32	1.82	1.82	10.06	21.78	8.87
2%$CaCl_2$+1% K_2SO_4	18.46	36.53	64.44	100	54.86	27.17	48.80	79.29	100	63.82
2%$CaCl_2$+1%K_2SO_4 +Bagging	0.45	0.45	5.33	11.61	4.46	1.12	1.12	8.80	18.38	7.35
Control	86.43	100	100	100	96.61	100	100	100	100	100
Mean	20.78	30.13	44.82	59.41	38.79	25.46	34.53	51.93	61.55	43.37
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
SEm±	2.15		0.84		2.45	2.18		1.02		2.87
P< 0.05	6.38		2.43		7.34	6.40		3.04		8.21

incidence of black spots, which increased their market appeal (Sarker *et al.,* 2009; Chonhenchob *et al.*, 2011). The above results are close confirmatory to earlier findings of Singh *et al.* (1987) and Burondkar *et al*. (2009).

Total Soluble Solids (TSS %)

The significantly maximum TSS content was recorded in fruits treated with 2% $CaCl_2$+1% K_2SO_4+bagging (18.20 and 18.40%), while the minimum was recorded in the control (15.41% and 15.60%) in both years, respectively (Table 6). The TSS content of mango fruits significantly increased with storage period, reached its peak, and then declined during the storage at ambient temperature in both years. The initial increase in TSS content might be due to the breakdown of starch and polysaccharides into simple sugars and organic acid during the subsequent storage, but later on, the decline in TSS content might be due their utilization in evapo-transpiration, respiratory process, and other biochemical activities (Koksal *et al*., 1994).

Table 6. Effect of pre-harvest nutrient application and bagging on Total Soluble Solids (TSS %) in mango fruits *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	8.97	15.50	19.77	19.07	15.83	9.17	15.62	19.88	19.26	15.98
2% $CaCl_2$	9.12	16.25	20.10	20.29	16.44	9.37	16.38	20.25	20.49	16.62
1% K_2SO_4	9.47	17.25	20.72	21.08	17.13	9.62	17.39	20.98	21.28	17.32
2%$CaCl_2$+Bagging	9.30	16.52	20.35	20.68	16.71	9.47	16.67	20.55	20.87	16.89
1%K_2SO_4+Bagging	9.55	17.60	20.95	21.22	17.33	9.82	17.72	21.15	21.44	17.53
2%$CaCl_2$+1% K_2SO_4	10.00	17.97	21.10	21.49	17.64	10.20	18.10	21.26	21.76	17.83
2%$CaCl_2$+1%K_2SO_4 +Bagging	10.20	18.27	21.92	22.39	18.20	10.37	18.43	22.12	22.66	18.40
Control	8.75	15.17	19.22	18.50	15.41	9.05	15.30	19.37	18.68	15.60
Mean	9.42	16.81	20.52	20.59	16.84	9.63	16.95	20.70	20.81	17.02
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
SEm±	0.15		0.09		0.32	0.14		0.09		0.32
P< 0.05	0.45		0.24		0.91	0.43		0.25		0.91

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The TSS content in the control and bagging increased upto 12th days of storage, whereas other treatments showed increasing trend upto 15th days and then declined during the storage period. Similarly, earlier reports have revealed that the pre-harvest spray of $CaCl_2$ and K_2SO_4 improve the TSS content of mango fruits (Karemera and Habimana, 2014; Burondkar *et al*., 2009). Watanawan *et al.* (2008) have also reported that the pre-harvest bagging improved the TSS content of in mango fruits.

Acidity (%)

The significantly maximum acidity content was recorded in the control (0.29 and 0.28%), while the minimum was recorded in the treatment of 2% $CaCl_2$+1% K_2SO_4+bagging (0.21 and 0.19%) in both years, respectively. Other treatments also showed lower acidity content in comparison to the control in both years (Table 7). The acidity content of mango fruits continuously decreased during the entire period of storage, probably due to the general catabolization of organic acids and their conversion into sugars (Mottoo *et al.*, 1975).The above results fall in line with the earlier reports of Dhahiya *et al*. (2001) and Karemera and Habimana (2014).

Ascorbic Acid (mg 100 g^{-1})

The highest ascorbic acid content was recorded in the treatment of 2% $CaCl_2$+1% K_2SO_4+bagging (57.00 and 56.70 mg 100 g^{-1}, respectively) which was found statistically at par with 2% $CaCl_2$+1% K_2SO_4 during storage in both years. The minimum ascorbic acid content was recorded in the control (42.60 and 42.23 mg 100 g^{-1}) in both years, respectively (Table 8). The ascorbic acid content of mango fruits significantly decreased with the advancement of storage period, probably due to the rapid conversion of L-ascorbic acid into dehydro-ascorbic acid in the presence of ascorbinase enzyme (Mapson, 1970).The above results are very close to the findings of Sharma *et al*. (1990) and Watanawan *et al.* (2008) in mango.

β-carotene (μg 100 g^{-1})

The highest *β*-carotene content was recorded in treatment of 2% $CaCl_2$+1% K_2SO_4+bagging (3566 and 3611 μg 100 g^{-1}) which was statistically at par with treatments 2% $CaCl_2$+1% K_2SO_4 (3534 and 3569 μg 100 g^{-1}) during storage in both years, respectively (Table 9). The lowest *β*-carotene content was noted in the control (2433 and 2450 μg 100 g^{-1}) in both the years,

Table 7. Effect of pre-harvest nutrient application and bagging on total acidity (%) in mango fruits *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	0.40	0.31	0.23	0.15	0.27	0.40	0.29	0.22	0.14	0.26
2% $CaCl_2$	0.39	0.29	0.21	0.14	0.26	0.38	0.28	0.20	0.13	0.25
1% K_2SO_4	0.37	0.28	0.20	0.12	0.24	0.37	0.25	0.17	0.10	0.22
2%$CaCl_2$+Bagging	0.37	0.27	0.21	0.12	0.24	0.38	0.27	0.19	0.12	0.24
1%K_2SO_4+Bagging	0.36	0.27	0.19	0.11	0.23	0.36	0.24	0.16	0.09	0.21
2%$CaCl_2$+1% K_2SO_4	0.35	0.26	0.18	0.10	0.22	0.34	0.24	0.15	0.08	0.20
2%$CaCl_2$+1%K_2SO_4 +Bagging	0.34	0.25	0.17	0.09	0.21	0.33	0.23	0.15	0.06	0.19
Control	0.42	0.33	0.25	0.16	0.29	0.41	0.32	0.23	0.15	0.28
Mean	0.37	0.28	0.21	0.12	0.25	0.37	0.26	0.18	0.11	0.23

	Treatments (t)	Storage days (d)	t×d	Treatments (t)	Storage days (d)	t×d
SEm±	0.004	0.002	0.007	0.002	0.002	0.32
P< 0.05	0.012	0.007	0.019	0.007	0.007	0.91

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Table 8. Effect of pre-harvest nutrient application and bagging on ascorbic acid (mg 100 g^{-1}) in mango fruits *cv*. Amrapali during the storage.

	2010-2011 Storage days					2011-2012 Storage days				
Treatment	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	51.26	44.68	42.79	40.18	44.73	50.91	44.31	42.43	39.81	44.37
2% $CaCl_2$	55.38	50.72	48.32	44.98	49.85	54.98	50.33	47.93	44.63	49.47
1% K_2SO_4	58.73	53.37	50.95	47.11	52.54	58.36	53.02	50.62	47.79	52.45
2%$CaCl_2$+Bagging	57.99	52.73	49.81	46.08	51.65	57.56	52.73	49.81	46.08	51.55
1%K_2SO_4+Bagging	60.61	55.44	52.79	49.88	54.68	60.25	55.16	52.83	49.58	54.46
2%$CaCl_2$+1% K_2SO_4	61.72	56.54	54.71	51.72	56.17	61.30	56.16	54.31	51.34	55.78
2%$CaCl_2$+1%K_2SO_4 +Bagging	62.17	57.34	55.58	52.91	57.00	61.97	57.08	55.19	52.56	56.70
Control	49.22	43.54	40.81	36.82	42.60	48.80	43.18	40.48	36.45	42.23
Mean	57.14	51.79	49.47	46.21	51.15	56.77	51.49	49.20	46.03	50.873
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
SEm±	0.34		0.17		0.47	0.36		0.26		0.53
P< 0.05	1.03		0.49		1.36	1.08		0.73		1.50

Table 9. Effect of pre-harvest nutrient application and bagging on *β*-carotene (µg 100 g^{-1}) in mango fruits *cv*. Amrapali during the storage.

	2010-2011 Storage days					2011-2012 Storage days				
Treatment	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	1110	3011	4211	5263	3399	1116	3023	4220	5277	3409
2% $CaCl_2$	1204	3032	4279	5297	3453	1219	3088	4289	5313	3477
1% K_2SO_4	1192	3029	4271	5275	3442	1201	3046	4282	5288	3454
2%$CaCl_2$+Bagging	1255	3077	4313	5341	3497	1267	3114	4335	5373	3522
1%K_2SO_4+Bagging	1233	3065	4293	5316	3477	1241	3099	4305	5345	3498
2%$CaCl_2$+1% K_2SO_4	1310	3084	4358	5385	3534	1324	3134	4392	5426	3569
2%$CaCl_2$+1%K_2SO_4 +Bagging	1333	3104	4411	5416	3566	1352	3185	4427	5481	3611
Control	992	2389	3101	3248	2433	1011	2407	3118	3265	2450
Mean	1204	2974	4155	5067	3350	1217	3012	4171	5096	3374
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
SEm±	22.78		15.79		32.51	21.92		16.14		27.89
P< 0.05	63.27		43.92		92.58	65.71		44.88		78.86

respectively. The *β*-carotene content of mango fruits significantly increased with the advancement of storage period, likely due to the breakdown of chlorophyll and increase in carotenoids content by chlorophyllase enzyme during the storage. Analogous observations to these findings have also been earlier reported in mango (Singh *et al*., 1998; Babu and Krishnamurthy, 1993).

Total Sugars (%)

The significantly highest total sugars content was recorded in treatment of 2% $CaCl_2$+1% K_2SO_4+bagging (14.71 and 15.16%), while the minimum was noted in the control (11.44 and 11.73%) in both years, respectively (Table 10). The sugars content in the control and bagging increased upto 12th days of storage, whereas other treatments showed increasing trend upto the 15th day and then declined during the storage period in both years. The initial increase in sugars content of fruits during storage might be because of an increase in reducing sugars and non-reducing sugars resulting from conversion of starch into simple sugars and, later on, reduction in sugar content mainly due to its utilization in respiration process

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Table 10. Effect of pre-harvest nutrient application and bagging on total sugars (%) in mango fruits *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	5.92	12.22	15.62	14.05	11.95	6.27	12.58	15.94	14.40	12.3
2% $CaCl_2$	6.29	12.65	15.78	15.40	12.53	6.61	12.99	16.12	15.75	12.87
1% K_2SO_4	7.23	13.77	17.08	16.89	13.74	7.58	14.08	17.47	17.16	14.07
2%$CaCl_2$+Bagging	6.85	13.03	16.16	15.68	12.93	7.18	13.14	16.53	16.05	13.23
1%K_2SO_4+Bagging	7.35	13.95	17.26	17.04	13.9	7.74	14.14	17.64	17.22	14.19
2%$CaCl_2$+1% K_2SO_4	7.66	14.55	17.90	17.54	14.41	7.99	14.83	18.32	18.12	14.82
2%$CaCl_2$+1%K_2SO_4 +Bagging	7.93	14.82	18.24	17.83	14.71	8.36	15.19	18.65	18.42	15.16
Control	5.28	11.71	15.09	13.67	11.44	5.63	12.04	15.39	13.84	11.73
Mean	6.81	13.34	16.64	16.01	13.20	7.17	13.62	17.00	16.37	13.54
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
SEm±	0.06		0.04		0.11	0.07		0.06		0.16
P< 0.05	0.19		0.11		0.32	0.22		0.16		0.45

(Banday, 1996). The above results corroborate the findings of Karemera and Habimana (2014) and Burondkar *et al*. (2009) in mango.

Organoleptic Evaluation

Fruits treated with 2% $CaCl_2$+1% K_2SO_4+bagging were found significantly superior in organoleptic quality with highest score (7.71 and 7.79, respectively) and rated as moderate, while the control obtained the lowest score (6.65 and 6.75, respectively) and rated as "nor like nor dislike" in both years (Table 11). However, all the pre-harvest treatments were found acceptable upto 12th day of storage against 6th day of the control, in both years. The above results fall in line with the findings of Hayat *et al*. (2003) who reported that the pre-harvest treatment of 2% $CaCl_2$ on apple *cv*. Banky retained the best general appearance, organoleptic quality, and consumer acceptability during storage. Similarly, Sharma *et al*. (2014) reported that the pre-harvest bagging improved the visual quality

Table 11. Effect of pre-harvest nutrient application and bagging on organoleptic quality of mango fruits *cv*. Amrapali during the storage.

Treatment	2010-2011 Storage days					2011-2012 Storage days				
	0	6	12	18	Mean	0	6	12	18	Mean
Bagging	7.42	8.45	8.21	5.42	7.38	7.51	8.57	8.29	5.46	7.46
2% $CaCl_2$	7.32	8.14	7.92	5.05	7.11	7.46	8.26	8.00	5.09	7.2
1% K_2SO_4	7.32	8.25	8.07	5.15	7.20	7.46	8.37	8.15	5.19	7.29
2%$CaCl_2$+Bagging	7.42	8.51	8.29	5.63	7.46	7.46	8.63	8.37	5.67	7.53
1%K_2SO_4+Bagging	7.42	8.62	8.38	5.77	7.55	7.51	8.74	8.46	5.81	7.63
2%$CaCl_2$+1% K_2SO_4	7.32	8.32	8.14	5.35	7.28	7.46	8.44	8.22	5.39	7.38
2%$CaCl_2$+1%K_2SO_4 +Bagging	7.42	8.81	8.56	6.03	7.71	7.51	8.93	8.64	6.07	7.79
Control	7.24	7.94	7.77	4.83	6.95	7.46	8.06	7.85	4.87	7.06
Mean	7.36	8.38	8.17	5.40	7.33	7.48	8.50	8.25	5.44	7.418
	Treatments (t)		Storage days (d)		t×d	Treatments (t)		Storage days (d)		t×d
SEm±	0.02		0.05		0.13	0.04		0.06		0.16
P< 0.05	0.07		0.13		0.36	0.12		0.16		0.45

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of fruit by promoting skin coloration and reducing blemishes, it also changed the micro-environment for fruit development, which can have several beneficial effects on internal fruit quality. Sarker *et al.* (2009) also reported that the bagging also improved the physical quality i.e., the incidence of black spots, of mango fruits, which increased their market appeal.

Shelf Life

Fruits treated with 2% $CaCl_2$+1% K_2SO_4+bagging showed the maximum shelf life up to 12th day with minimum weight loss (7.94% and 7.57%, respectively) in both years. Although, other treatments *viz.* 2% $CaCl_2$+bagging, 2% $CaCl_2$+ 1% K_2SO_4 and 2% $CaCl_2$, also showed the shelf life up to 12 days and appeared to be the second, third and fourth, respectively, in minimizing weight loss of mango fruits in both years. Other treatments, including the control, showed the shelf life up to only 6th day, while the maximum weight loss (12.88 and 12.55%) was recorded in untreated fruits (control) in both years, respectively (Table 3). Similarly, Karemera and Habimana (2014) have also reported that the trees sprayed with 1.50% CaCl2 at 30 days before harvest extended the shelf life of mango *cv*. Totapuri up to 25.89 days and physical-chemical proprieties were also improved compared to fruits from non-sprayed trees**.** Burondkar *et al*. (2009) also reported the effect of 1% K_2SO_4 on shelf life of mango fruits by reducing the weight loss. Signes *et al.* (2007) reported that pre-harvest bagging delayed ripening resulting in extended shelf life of 'Perla', a black table-grape.

CONCLUSIONS

Thus, it is concluded that the pre-harvest treatment of 2% $CaCl_2$+1% K_2SO_4+bagging was found to be the best to increase the fruits quality in respect of fruits weight, firmness, TSS, ascorbic acid, total sugars and *β*-carotene, with minimum weight loss and black spotting in mango fruits *cv*. Amrapali and maintained it throughout the entire period of storage. Treated fruit can be stored upto 12 days with minimum weight loss, highest organoleptic quality, and acceptability during the storage. Therefore, the pre-harvest treatment of 2% $CaCl_2$+1% K_2SO_4+bagging is suggested to the mango traders and grower of India for taking a quality production with prolonged shelf life to obtain a profitable price of mangoes in domestic and export markets.

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اثر کاربرد عناصر غذایی و کیسه بندی پیش از برداشت روی کیفیت و انبارداری میوه انبه (*Mangifera indica* L.)کولتیوار Amrapali

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چکیده

هدف پژوهش حاضر مطالعه اثرکیسه بندی و پاشیدن $CaCl_2$و K_2SO_4پیش از برداشت محصول روی کیفیت و انبارداری میوه انبه کولتیوار Amrapali در طی دو سال پی در پی بود. محلول های مزبور در سه نوبت شامل ۳۰، ۲۰، و ۱۰ روز قبل از برداشت روی درختان این رقم انبه پاشیده شد و ۲۰ روز قبل از چیدن محصول، میوه ها داخل پاکت های کاغذ قهوه ای قرار داده شدند. میوه های چیده شده در انباری با حرارت محیط قرار داده شد و تا ۱۸ روز به طور سه روز درمیان از آنها بازدید شده و مشاهدات ثبت می شد. داده ها حاکی از آن بود که بهترین نتیجه برای بهبود کیفیت میوه ها از نظر بیشترین وزن میوه، TSS، اسید اسکوربیک، قند کل، و محتوای β-caroteneو داشتن کمترین مقدار لکه های سیاه و حفظ این خواص تا ۱۸ روز انبارداری با پاشش محلول ۲٪$CaCl_2$ و۱٪K_2SO_4 +کیسه بندی پیش از برداشت به دست می آید. میوه هایی که با ۲٪$CaCl_2$ و۱٪K_2SO_4 +کیسه بندی تیمار شده بودند کمترین کاهش وزن و بیشترین خواص کیفیت های حسی (طعم، رنگ، بو) را تا ۱۲ روز انبار داری حفظ کرده بودند در حالی که برای میوه های تیمار نشده (شاهد) این دوره شش روز بود.

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