Aswan University Journal of Science and Technology Volume 4, issue 4

EFFECTS OF POTASSIUM, BORON AND FULVIC ACID SPRAYING ON QUALITY AND SHELF LIFE OF ZEBDA MANGO FRUITS

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ABSTRACT

The effect of potassium, boron and fulvic acid spraying on quality and shelf life of Zebda mango fruits was study during three successive seasons 2021, 2022 and 2023. Fruits were harvested and directly transported to the laboratory where washed and dried then treated. The treated fruits were packaged in carton boxes and kept at room temperature during shelf life for 15 days. Fruit samples were taken at harvest and at five days intervals during shelf life to evaluate fruit quality and storability. Treated fruits with potassium, boron and fulvic acid significantly reduced the deterioration of physical and chemical characteristics. Moreover, this study confirmed that, treatments effectively increased fruit storability comparison to untreated fruits (control). This study illustrated that, spraying either of potassium and boron or potassium and boron plus fulvic acid are the promising strategy for keeping postharvest quality and increasing shelf life and marketing period of mangoes cv. 'Zebda' up to 15 days.

INTRODUCTION

Mango (*Mangifera indica* L.) is an economically and popular important tropical fruit in the world and also in Egypt. The total planted area of mango orchards in Egypt reached of 326626 feddans with annually total production of 1280310 tons (Statistics of Ministry of Agriculture and land reclamation, **[1]** Mango fruit quality consists of many attributes that are considered the key components that contribute to a high quality fresh mango and in the consumer acceptability. They include texture, sweetness, acidity, flavor, volatiles, aroma, nutritional value, chemical components, appearance of flesh colour and shelf life Mango is a climacteric fruit, it has poor storage life and the fruit ripening rapidly after harvesting, which greatly affects a loss in commercial value and ripe

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Received September 7, 2024, received in revised form, October 1, 2024, accepted October 2, 2024.
(ASWJST 2021/ printed ISSN: 2735-3087 and on-line ISSN: 2735-3095) https://journals.aswu.edu.eg/stjournal

fruits. It becomes much more susceptible to pathogen infections, due to the reduction in peel impedance and the raising of pulp softening, availability of water and sugars **[2]** Natural products are taking a place as an alternative approach for retardant ripening and decreasing postharvest deterioration of fruit **[3]**

Potassium (K) is involved in quality-related characteristics of fruit and is called a quality element **[4]** It is crucial for many biochemical reactions that are essential for enzyme activation and physiological processes in cell **[5]** These reactions play a major role in ion transport between cells and stomatal conductance under different climatic variables (temperature, light, humidity), thus affect fruit quality **[6]** Fruit size, appearance, color, soluble solids, acidity, vitamin content, taste, as well as shelf-life are significantly influenced by an adequate supply of K **[7]**. It increases the tolerance of plants for many stresses: drought, excessive water, salt stress, high and low-temperature stresses **[8, 9]** Application of additional potassium via foliar spray or nutrient solution has been shown to improve many growth and fruit biochemical characteristics in crops such as strawberry, olives and passion fruit **[10, 7]**.

To get mangoes with longer shelf life in extreme temperatures of summer, a pre-harvest spray of Ca can also be effective. In fruits many disorders are relevant to B deficiency, even when B is in ample supply, suggesting these disorders are physiological in nature and related to the mobility of B in the plant tissues**[11]** . Besides disorders, fruit setting and retention percentage of fruit are attributed to B concentration in fruit **[12]** It is documented fact that less bioavailability of B in floral structure, resulted in low fruit setting from flowers and their retention percentage on panicle. **[13]** reported the effects of Ca and B on pollen germination and fruit set in mango cv. Mahachanok. Their investigations showed a significant positive effect on pollen germination and fruit setting with co-application of Ca and B at 3.0 ml/L. With application of K, Ca and B efficient increase in fruit set and fruit retention, as well as fruit quality characteristics of mango is expected. Therefore, the current study was designed with the objective to examine the effects of foliar application of boric acid alone and in combination with various sources and Ca and K on yield and quality of mango cv. Summer Bahisht (SB) Chaunsa in changing climate conditions.

Fulvic acid increases the photosynthetic rate and reduces the opening of stomata and the transpiration rate to regulate plant growth as well as, enhances mineral element absorption **[14, 15]** Besides, it improves the transfer of minerals directly inside the plant cells and chelates mineral nutrients **[16]** Fulvic acid significantly increased leaf surface area, fruit number per tree, fruit weight, TSS% and total sugars **[17, 18, 19]** Shelf life is the period of time fruits retained its microbial safety, nutritive value and sensorial attributes begins from the time the fruits are manufactured to its starts of deterioration. During this period, the fruits remained acceptable without significantly, losing its sensory, chemical, physical, functional, microbiological and nutritional properties under different packaging material and storage condition **[20]** Proper temperature and relative humidity are critical to obtain an extended shelf life of stored fruits. When harvested fruits stored at higher than critical temperatures set for recognized produce, the storage life will be shortened. Similarly, if harvested fruits are stored at a lower than critical temperatures set by scientific organization for selected produce, their shelf life could be affected by either freezing or chilling injury.

Then, this research amid to study the effect of potassium, boron and fulvic acid on postharvest of mango fruits to solve the postharvest problems and improve the shelf life of mangoes.

Materials and Methods

The present study was conducted during the three consecutive seasons of 2021, 2022 and 2023 in a private mango orchard situated at Al-Brahma Qift district, Qena governorate where the texture of the soil is clay with a water table depth not less than two meters. Twenty four old Zebda mango trees budded on mango seedling rootstocks, and planted at 7x7 meters apart were selected for this study. Eight nutrition treatments were applied. Three foliar applications of potassium citrate, boron and potassium vulvate was applied for the three seasons in 1st March at the growth stage, first week of April at fruit setting stage, and after one month in the first week of May. The eight spray treatments as follow:

T1: spraying water (control)

T2: spraying 0.5% boron

T3: spraying 1% potassium citrate

T4: spraying 1% potassium vulvate

T5: spraying 0.5% boron plus 1% potassium citrate (double form)

T6: spraying 0.5% boron plus 1% potassium vulvate (double form)

T7: spraying 1% potassium citrate plus 1% potassium vulvate (double form)

T8: spraying 0.5% boron, 1% potassium citrate and 1% potassium vulvate (triple form)

All mango trees received the regular agricultural and horticultural practices, which were already followed in the mango orchard including pruning, hoeing, irrigation with Nile water as well as pests, pathogens, and weed control. Harvest fruits were transported directly to the laboratory. Fruits were washed with distilled water and their surface disinfected with a 1% sodium hypochlorite solution, then air-dried before used. The treated fruits were packaged in carton boxes and kept at room temperature during shelf life fruit samples were taken at harvest time and at five days intervals of shelf life period to evaluated fruit quality.

Generally, the following measurements were recorded during the three studied seasons.

Weight loss percentage was calculated by the following equation:

[(initial fruit weight - fruit weight at examination date) / (initial fruit weight)] × 100.

Decayed fruit percentage was determined as follow [(number of decayed fruits at examination date) / (initial number of fruits)] ×100.

Fruit firmness of the flesh was recorded by using texture analyzer Instrument. The force required to penetrate 1 cm inside the fruit using a needle probe diameter of 5 mm was measured. The machine was set with peak mode and speed of 0.3 mm/sec. Readings were recorded on three points in the equatorial region of the whole fruit and the results were expressed as the resistance force to the penetrating tester in units of pressure g/cm^2 **[21]**

Fruit juice was extracted by crushing the pulp of each fruit and fruit juice strained through a muslin cloth and used for measuring internal fruit quality as follow:

Fruit content of total soluble solids (TSS) was determined by hand refractometer, 0-32 scale (ATAGO N-1E, Japan) and expressed in °Brix after making the temperature correction at 20°C according to **[22]**

The percentages of total and reducing sugars were determined according to the volumetric method of Lane and Eynon outlined in **[22]**

Fruit content of titratable acidity (TA) was determined as per the procedure of **[22]** Aliquot of fruit juice was taken and titrated against 0.1 N NaOH in the presence of phenolphthalein as an indicator to the end point and was calculated as grams of citric acid/100 ml of the juice.

The amount of vitamin C in fruit juice was measured as mg ascorbic acid per 100 ml juice using the 2, 6-dichlorophenolindo-phenol blue dye **[22]**

The experiment was arranged in a randomized complete block design having three replications **[23]** and consisting of two factors (pre-harvest treatments and shelf life periods). This experiment was analysis as factorial. Data calculated as percentage were transformed to arcsine of square root before statistical analysis and non-transformed means are shown. The effects of treatments and cold storage periods on different attributes were analyzed statistically by analysis of variance (ANOVA) using the MSTAT-C statistical package **[24]**Comparisons between means were done at probability ≤ 0.05.

Results

1-The percentage of fruit weight loss and fruits damage:

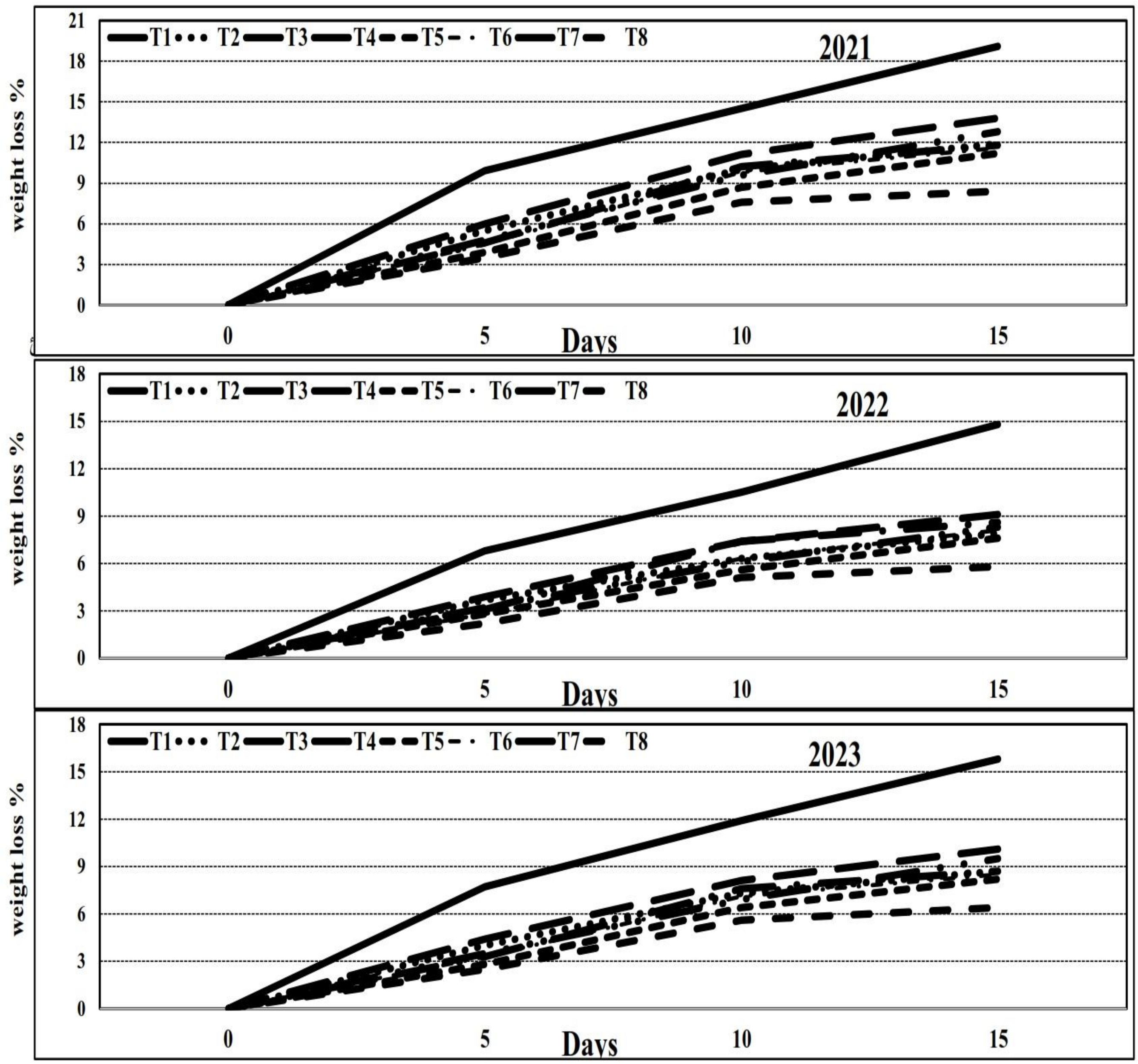
Data presented in Figures (1, 2) showed the effect of potassium, boron and fulvic acid on the percentage of weight loss and fruits damage of Zebda mangoes during the shelf life in 2021, 2022 and 2023 seasons. It was obvious that results took similar trend during the three studied seasons. Data in current figures clear that fruit weight loss and fruits damage percentage were markedly increased with advance of shelf life period. These traits were significantly increased gradually from the beginning of shelf life till the 15 days. Weight loss and damage percentage increased during shelf life, reaching values of (12.6, 8.8 & 9.5%) and (12.9, 11.1 & 12.0%) after 15 days. The weight loss was significantly increased and attained (0.0, 5.3, 10.2 & 12.6), (0.0, 3.6, 6.8 & 8.8) and (0.0, 3.9, 7.6 & 9.5%) due to shelf life for 0, 5, 10 and 15 days during the three studied seasons, respectively. Also, the corresponding values of damage percentage was attained (0.0, 6.5, 11.0 & 12.9), (0.0, 5.7, 9.6 & 11.1) and (0.0, 6.1, 10.3 & 12.0%), respectively.

In response of treatment effects, it was apparent that all spraying treatments significantly decreased the fruit weight loss percentage and damage fruit percentage during shelf life compared with control. Using triple form (boron and potassium plus fulvic acid) gave the best results, which gave the least percentage of fruit weight loss (4.9, 3.3 & 3.6%) and fruit damage (5.2, 4.8 & 5.2%). The weight loss was attained (10.9, 6.8, 7.7, 6.9, 6.0, 6.5, 6.7 & 4.9), (8.0, 4.4, 5.1, 4.5, 4.0, 4.3, 4.8 & 3.3) and (8.9, 5.0, 5.7, 5.0, 4.4, 4.7 4.9 & 3.6%) due to control (T1), boron (T2), potassium citrate (T3), fulvic acid (T4), boron plus potassium citrate (T5), boron plus fulvic acid (T6), potassium citrate plus fulvic acid (T7) or boron and potassium citrate plus fulvic acid (T8) during the three studied seasons, respectively. The corresponding, damage fruits percentage was attained (12.6, 7.2, 7.4, 8.2, 6.2, 7.0, 7.1 & 5.2), (11.0, 6.1, 6.4, 7.1, 5.4, 6.0, 6.1 & 4.8) and (11.7, 6.6, 6.96, 7.7, 5.9, 6.5, 6.5 & 5.2%) respectively. No significant differences in weight loss and fruit damage due to spray potassium citrate alone, potassium citrate (T3) plus boron or fulvic acid (duple form, T5, T6 & T7). The decrement percentage of weight loss percentage attained (37.61, 44.95, 40.37, 38.53 & 55.05), (45.0, 50.0, 46.25, 40.0 & 58.75) and (43.82, 50.56, 47.19, 44.49 & 59.55%), as well as damage fruit percentage attained (42.86, 50.79, 44.44, 43.65 & 58.73), (44.55, 50.91, 45.45, 44.54 & 56.36) and (43.59, 49.57, 44.44, 44.44 & 55.56%) due to T3, T5, T6, T6 and T8 compared to spray water (control, T1) during the three studied seasons, respectively.

Data also cleared that, there was a significant interaction among treatments and shelf life periods for weight loss and decay percentages of mango fruits in both seasons in this research the weight loss was attained (19.1 ,11.9, 12.8, 13.8, 11.2, 11.6, 11.8 & 8.4%), (14.8, 7.9, 8.3, 9.1, 7.6, 8.1, 8.6 & 5.8) and (15.8, 8.7, 9.5, 10.1, 8.2, 8.5, 8.7 & 6.4%) due to T1 to T8, during the three studied seasons, respectively. The corresponding, damage fruits percentage was attained (21.1, 12.1.8, 12.6, 14.0, 11.0, 11.9, 11.9 & 8.6), (17.8, 10.2, 10.6, 11.9, 9.6, 10.1, 10.3 & 8.2) and (19.6, 11.1, 11.4, 12.8, 10.4, 10.9, 11.1 & 8.9%) respectively.

The variation in reduction of fruit loss and fruit damage depends on the spraying type used where, use potassium citrate plus boron gave the least percentage of fruit weight loss and induce a least percentage of decayed fruits compared to the other treatments. The results indicated that using potassium citrate alone or plus boron proved effective in reducing the percentage of weight loss and fruit damage as well as keeping the mango fruits for long period

Fig (1) Effect of preharvest treatments on weight loss % of Zebda mangoes during shelf life in



(Average of Three Years)

T1- Control. T2- Potassium citrate. T3- boron. T4- Fulvic.
T5- B/k. T6- B/F. T7- F/k. T8- k/B/F.

2021, 2022 and 2023 seasons.

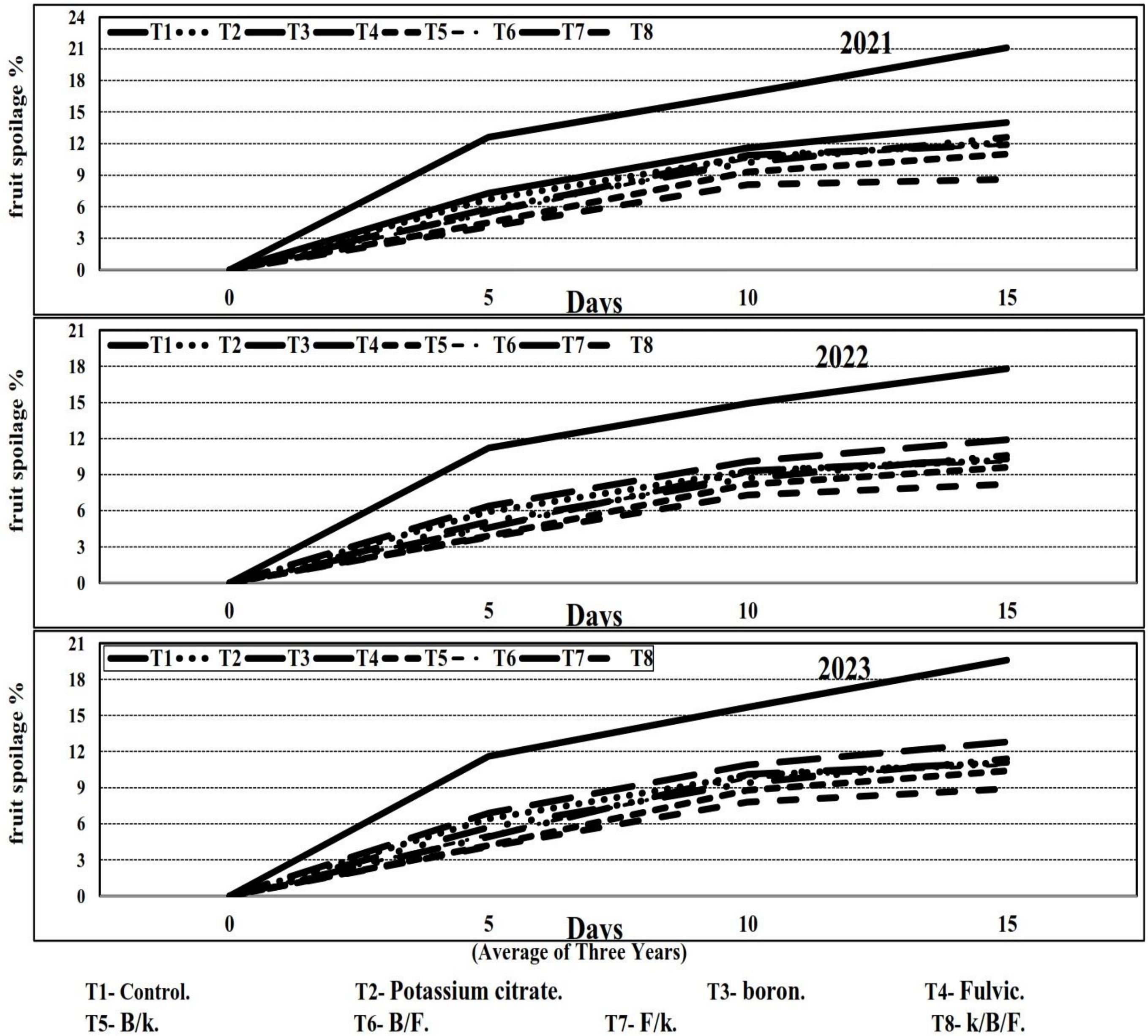


Fig (2) Effect of preharvest treatments on fruit spoilage % of Zebda mangoes during shelf life in 2021, 2022 and 2023 seasons.

2-The firmness:

Data presented in Table (1) showed the effect of potassium citrate, boron and fulvic acid on the firmness of Zebda mangoes during the shelf life in 2021, 2022 and 2023 seasons. It was obvious that results took similar trend during the three studied seasons. Data in current tables clear that the firmness was markedly decreased with advance of shelf life period. This trait was significantly decreased from the beginning of shelf life till the 15 days. The firmness decreases during shelf life, reaching values of (150.7, 157.8 g/cm^2) after 15 days during the three studied seasons, respectively.

In response of spraying types, it was apparent that all spraying treatments increased the firmness during shelf life compared with control. Using potassium citrate and boron (T5) or potassium citrate and boron plus fulvic acid (T8) gave the best results, which gave the highest the firmness (190.2, 197.1 & 191.8) and (191.5, 199.0 & 202.7 g/cm^2). No significant differences in firmness due to use potassium citrate and boron or potassium citrate and boron plus fulvic acid during the three studied seasons, respectively.

The fruit firmness was (152.9, 175.7, 183.0, 165.5, 1920.2, 186.5, 182.3 & 191.5) and (159.4, 183.8, 190.6, 172.5, 197.1, 193.2, 189.4 & 199.0) and (157.0, 181.2, 187.3, 168.4, 191.8, 189.1, 185.4 & 202.7 g/cm^2) due to use T1 to T8 during the three studied seasons, respectively.

Data also cleared that, there was a significant interaction among treatments and periods for the firmness of mango fruits in three seasons the firmness was attained (112.3, 148.8, 160.9, 136.8, 163.9, 162.5, 155.2 & 164.9), (116.9, 158.8, 168.4, 142.1, 171.2, 170.0, 161.5 & 173.2) and (113.6, 153.8, 162.9, 135.6, 165.4, 165.1, 158.3 & 166.4 g/cm^2) due to T1 to T8, during the three studied seasons, respectively. Hence, increment percentage of firmness attained 35.50, 43.28, 21.81, 45.95, 44.71, 38.20 & 46.84), (35.84, 44.05, 21.16, 46.45, 45.42, 38.15 & 48.16) and (35.39, 43.40, 19.37, 45.60, 45.33, 39.35 & 46.48 %) due to use T2 to T8 compared to (control, T1) during the three studied seasons, respectively. No significant differences in firmness due to use potassium citrate and boron or potassium citrate and boron plus fulvic acid during the three studied seasons, respectively.

The variation in reduction of firmness depends on the spraying type used where, use potassium citrate and boron or potassium citrate and boron plus fulvic acid gave the highest firmness of fruits compared to the other treatments. The results indicated that using potassium citrate and boron treatments proved effective in reducing the firmness, hence, keeping the mango fruits for long period of shelf life with best fruit quality and appearance.

Table (1): Effect of preharvest treatments on firmness (g/cm2) of Zebda mangoes during shelf life in 2021, 2022 and 2023 seasons.

Season	2021					2022					2023				
T / D	0.0	5	10	15	M	0.0	5	10	15	M	0.0	5	10	15	M
Control	210.8	156.9	131.6	112.3	**152.9**	218.5	163.4	138.7	116.9	**159.4**	219.8	159.4	135.2	113.6	**157.0**
Boron (B)	211.9	179.8	162.4	148.8	**175.7**	218.0	188.3	170.1	158.8	**183.8**	218.4	185.1	167.3	153.8	**181.2**
Potassiu Citrate (K)	213.5	189.1	168.3	160.9	**183.0**	220.1	198.8	175.1	168.4	**190.6**	221.3	194.6	170.3	162.9	**187.3**
Fulvic (F)	214.6	164.2	146.5	136.8	**165.5**	220.8	172.7	154.3	142.1	**172.5**	219.2	168.7	149.9	135.6	**168.4**
B/k	216.9	198.2	181.8	163.9	**190.2**	223.5	205.4	188.3	171.2	**197.1**	222.1	198.8	180.9	165.4	**191.8**
B/F	215.3	191.8	176.4	162.5	**186.5**	217.8	201.0	183.8	170.0	**193.2**	218.6	195.4	177.4	165.1	**189.1**
F/k	216.9	186.2	170.8	155.2	**182.3**	221.9	195.8	178.3	161.5	**189.4**	220.8	189.5	173.1	158.3	**185.4**
k/B/F	218.1	198.9	184.0	164.9	**191.5**	220.9	208.4	193.4	173.2	**199.0**	221.1	234.2	189.2	166.4	**202.7**
Mean	**214.8**	**183.1**	**165.2**	**150.7**		**220.2**	**191.7**	**172.8**	**157.8**		**220.2**	**190.7**	**167.9**	**152.6**	
L.S.D	**A**:11.3 **B**:11.6 **AB**:23.1					**A**:10.8 **B**:11.2 **AB**:22.4					**A**:12.5 **B**:15.6 **AB**:31.2				

3-Fruit characteristics:

Data presented in Tables (2 to 5) showed the effect of potassium citrate, boron and fulvic acid on the fruit characteristics of Zebda mangoes during the shelf life in 2021, 2022 and 2023 seasons. It was obvious that results took similar trend during the three studied seasons. Data in tables (2 and 3) clear that total soluble solids (TSS) and total sugars were markedly increased with advance of shelf life period. These traits were significantly increased gradually from the beginning of shelf life till the 15 days. TSS and total sugars increased shelf life, reaching values of (15.0, 13.7 & 13.2%) and (11.48, 10.37 & 9.78%) after 15 days. TSS was significantly increased and attained (13.4, 13.9, 14.6 & 15.0), (12.2, 12.7, 13.4 & 13.7) and (11.8, 12.3, 12.8 & 13.2 %) and (10.17, 10.58, 11.03 & 11.48), (9.25, 9.63, 10.12 & 10.37) and (8.75, 9.13, 9.51 & 9.78%) due to shelf life for 0, 5, 10 and 15days during the three studied seasons, respectively.

In response of treatments effects, it was apparent that potassium citrate plus boron or (double form, T5, T6 and T7) or potassium citrate and boron plus fulvic acid (triple from, T8) significantly increased the TSS (14.8, 13.5 & 12.9) and sugar contents (11.20, 10.33 & 9.64%) during shelf life during the three studied seasons, respectively. Using triple form gave the best results, which gave the least increment percentage of TSS and total sugar as the end of shelf life compared to the beginning shelf life period. The TSS was attained (13.8, 13.8, 14.0, 13.8, 14.4, 14.3, 14.8 & 14.8), (12.4, 12.6, 13.1, 12.6, 13.3, 13.1, 13.5 & 13.5) and (12.0, 12.2, 12.2, 12.5, 12.8, 12.6, 12.9 & 12.9%) and total sugar (10.50, 10.73, 10.60, 10.62, 10.93, 10.86, 11.07 & 11.20), (9.58, 9.56, 9.76, 9.56, 9.98, 9.89, 10.10 & 10.33) and (9.05, 9.03, 9.26, 9.02, 9.44, 93.7, 9.54 & 9.64%) due T1 to T8 during the three studied seasons,respectively . No significant differences in TSS and total sugars due to use double or triple form of spraying.

The increment percentage of TSS attained (4.35, 3.62, 7.25 & 7.25), (7.26, 5.65, 8.89 & 8.89) and (6.67, 5.0, 7.5 & 7.5%), due to use T5, T6, T7 and T8 compared to (control, T1) during the three studied seasons, respectively.

Data also cleared that, there was a significant interaction among treatments and shelf life periods for TSS and sugars contents percentages of mango fruits in three seasons. The TSS was attained (14.8, 14.7, 14.6, 14.8, 15.1, 14.8, 15.4 & 15.4), (13.3, 13.4, 13.9, 13.2, 13.9, 13.7, 14.1 & 14.0) and (12.8, 12.9, 12.8, 13.9, 13.4, 13.2, 13.6, 13.5 & 13.5%) due to use T1 to T8 during the three studied seasons, respectively.

The increment percentage of TSS attained (2.03, 0.0, 4.05 & 4.05), (4.51, 3.01, 6.02 & 5.26) and (4.96, 3.13, 6.25 & 5.47%), due to use T5, T6, T7 and T8 compared to (control, T1) at the end of shelf life period during the three studied seasons, respectively. Also, the increment percentage of TSS attained (17.46, 10.22 & 8.45), (15.93, 11.21 & 9.38) and (17.43, 11.67 & 9.76%) due to T1, T5 and T8 and the end shelf life period compared to the beginning of shelf life.

These results show that the increase resulting from using the double form (potassium citrate plus boron) is less than the increase resulting from the spraying water (control) compared to the beginning of the shelf life period. Therefore, it is recommended to use the double form, which preserves the characteristics and quality of the fruits.

Also, data in tables (4 and 5) clear that vitamin C and total acidity were markedly decreased with advance of cold storage period. These traits were significantly increased gradually from the beginning of shelf life till the 15 days. Vitamin C and total acidity decreased during shelf life, reaching values of (27.3, 25.4 & 24.3 mg/100ml) and (0.46, 0.51 & 0.53%) after 15 days. Vitamin C was significantly decreased and attained (33.5, 30.9, 29.4 & 27.3), (31.0, 28.8, 27.3 & 25.4)and (29.6, 27.5, 26.2 & 24.3%) due to for 0, 5, 10 and 15 during the three studied seasons, respectively.

In response of treatment types, it was apparent that all treatments significantly increased the vitamin C and significantly decreased total acidity during shelf life compared with control. Using double or triple form gave the best results, which gave the highest vitamin C and least acidity. The vitamin C was attained (31.1, 31.3, 31.6 & 31.8), (28.8, 29.0, 29.2 & 29.4) and (27.6, 27.6, 28.1 & 28.2 mg/100 ml) due to T5, T6, T7 & T8 during the three studied seasons, respectively.

Data also cleared that, there was a significant interaction among treatments and shelf life periods for vitamin C and total acidity percentages of mango fruits in three seasons. The vitamin C was attained (24.8, 26.5, 27.1, 26.2, 28.1, 28.3, 28.5 & 28.6), (23.1, 24.8, 25.3, 24.4, 26.1, 26.3, 26.5 & 26.4) and (22.12, 23.6, 24.1, 23.3, 25.0, 25.2, 25.4 & 25.4 mg/100ml) and acidity was attained (0.49, 0.46, 0.46, 0.48, 0.46, 0.45, 0.46 & 0.44), (0.54, 0.51, 0.51, 0.53, 0.50, 0.50, 0.51 & 0.49) and (0.56, 0.53, 0.53, 0.55, 0.52, 0.52, 0.53 & 0.51) due to T to T8, during the three studied seasons, respectively.

These results show that the decrease of V.C and acidity percentage resulting from using the double form (potassium citrate plus boron) is less than the decrease resulting from the spraying water (control) compared to the beginning of the shelf life period. Therefore, it is recommended to use the double form, which preserves the characteristics and quality of the fruits.

Table (2): Effect of preharvest treatments on TSS % of Zebda mangoes during shelf life in 2021, 2022 and 2023 seasons.

Season	2021					2022					2023				
T / D	0.0	5	10	15	M	0.0	5	10	15	M	0.0	5	10	15	M
Control	12.6	13.6	14.2	14.8	**13.8**	11.3	12.2	12.8	13.3	**12.4**	10.9	11.8	12.4	12.8	**12.0**
Boron (B)	13.0	13.5	14.1	14.7	**13.8**	12.0	12.3	12.8	13.4	**12.6**	11.6	11.8	12.3	12.9	**12.2**
Potassium citrate (K)	13.2	13.7	14.4	14.6	**14.0**	12.3	12.6	13.4	13.9	**13.1**	11.6	11.8	12.4	12.8	**12.2**
Fulvic (F)	12.8	13.4	14.2	14.8	**13.8**	11.8	12.3	13.1	13.2	**12.6**	11.9	12.1	12.8	13.9	**12.5**
B/k	13.7	14.1	14.8	15.1	**14.4**	12.5	13.0	13.6	13.9	**13.3**	12.0	12.6	13.1	13.4	**12.8**
B/F	13.5	14.0	14.7	14.8	**14.3**	12.3	12.9	13.5	13.7	**13.1**	11.8	12.5	13.0	13.2	**12.6**
F/k	14.0	14.5	15.2	15.4	**14.8**	12.6	13.3	13.8	14.1	**13.5**	12.0	12.7	13.3	13.6	**12.9**
k/B/F	14.2	14.6	15.1	15.4	**14.8**	12.8	13.3	13.8	14.0	**13.5**	12.3	12.7	13.2	13.5	**12.9**
Mean	**13.4**	**13.9**	**14.6**	**15.0**		**12.2**	**12.7**	**13.4**	**13.7**		**11.8**	**12.3**	**12.8**	**13.2**	
L.S.D	**A**:0.41 **B**:0.39 **AB**:0.77					**A**:0.35 **B**:0.32 **AB**:0.64					**A**:0.37 **B**:0.33 **AB**:0.66				

Table (3): Effect of preharvest treatments on total sugar % of Zebda mangoes during shelf life in 2021, 2022 and 2023 seasons.

Season	2021					2022					2023				
T / D	0.0	5	10	15	M	0.0	5	10	15	M	0.0	5	10	15	M
Control	9.63	10.32	10.81	11.25	10.50	8.77	9.39	9.86	10.30	9.58	8.28	8.91	9.32	9.68	9.05
Boron (B)	9.88	10.25	10.68	12.10	10.73	8.99	9.35	9.78	10.12	9.56	8.50	8.83	9.21	9.56	9.03
Potassium citrate (K)	10.05	10.39	10.85	11.10	10.60	9.11	9.45	9.86	10.61	9.76	8.64	8.97	9.41	10.0	9.26
Fulvic (F)	9.73	10.18	10.93	11.62	10.62	8.86	9.26	9.95	10.15	9.56	8.36	8.78	9.35	9.58	9.02
B/k	10.38	10.68	11.18	11.48	10.93	9.45	9.74	10.21	10.50	9.98	8.96	9.22	9.67	9.92	9.44
B/F	10.31	10.70	11.13	11.31	10.86	9.34	9.70	10.20	10.32	9.89	8.86	9.25	9.61	9.74	9.37
F/k	10.61	11.02	11.26	11.38	11.07	9.68	10.0	10.29	10.41	10.10	9.15	9.48	9.70	9.82	9.54
k/B/F	10.75	11.10	11.39	11.56	11.20	9.81	10.12	10.83	10.55	10.33	9.23	9.58	9.81	9.94	9.64
Mean	10.17	10.58	11.03	11.48		9.25	9.63	10.12	10.37		8.75	9.13	9.51	9.78	
L.S.D	**A**:0.32 **B**:0.29 **AB**:0.56					**A**:0.27 **B**:0.25 **AB**:0.51					**A**:0.25 **B**:0.23 **AB**:0.46				

Table (4):

Season	2021					2022					2023				
T / D	0.0	5	10	15	M	0.0	5	10	15	M	0.0	5	10	15	M
Control	3.13	3.41	3.75	3.70	3.50	2.75	2.93	3.08	3.19	2.99	3.83	3.05	3.18	3.31	3.34
Boron (B)	3.25	3.38	3.50	3.65	3.45	2.80	2.92	3.05	3.16	2.98	2.91	3.01	3.14	3.26	3.08
Potassium citrate (K)	3.31	3.41	3.61	3.74	3.52	2.82	2.95	3.10	3.31	3.05	2.95	3.05	3.21	3.39	3.15
Fulvic (F)	3.22	3.35	3.56	3.63	3.44	2.76	2.89	3.08	3.17	2.98	2.86	3.0	3.18	3.30	3.09
B/k	3.38	3.55	3.66	3.80	3.60	2.93	3.06	3.16	3.28	3.11	3.04	3.15	3.31	3.39	3.22
B/F	3.40	3.51	3.68	3.71	3.58	2.92	3.03	3.14	3.21	3.08	3.05	3.13	3.28	3.34	3.20
F/k	3.49	3.62	3.72	3.75	3.65	3.02	3.12	3.21	3.25	3.15	3.11	3.24	3.30	3.35	3.25
k/B/F	3.48	3.65	3.73	3.81	3.67	3.08	3.16	3.32	3.34	3.23	3.14	3.25	3.34	3.37	3.28
Mean	3.33	3.49	3.65	3.72		2.89	3.01	3.14	3.24		3.11	3.11	3.24	3.34	
L.S.D	**A**:0.11 **B**:0.10 **AB**:0.20					**A**:0.11 **B**:0.11 **AB**:0.22					**A**:0.12 **B**:0.13 **AB**:0.26				

Table (5): Effect of preharvest treatments on V.C (mg/100g) of Zebda mangoes during shelf life in 2021, 2022 and 2023 seasons

Season	2021					2022					2023				
T / D	0.0	5	10	15	M	0.0	5	10	15	M	0.0	5	10	15	M
Control	**31.5**	**28.6**	**26.7**	**24.8**	**27.9**	**29.3**	**26.6**	**24.8**	**23.1**	**26.0**	**28.3**	**25.4**	**23.7**	**22.12**	**24.9**
Boron (B)	**32.5**	**30.1**	**28.6**	**26.5**	**29.4**	**30.2**	**28.1**	**26.7**	**24.8**	**27.5**	**28.9**	**26.8**	**25.5**	**23.6**	**26.2**
Potassium citrate (K)	**33.1**	**30.6**	**29.2**	**27.1**	**30.0**	**30.8**	**28.5**	**27.2**	**25.3**	**28.0**	**29.5**	**27.2**	**26.0**	**24.1**	**26.7**
Fulvic (F)	**32.1**	**29.7**	**28.3**	**26.2**	**29.1**	**29.9**	**27.6**	**26.3**	**24.4**	**27.1**	**26.8**	**26.4**	**25.2**	**23.3**	**25.4**
B/k	**34.3**	**31.7**	**30.2**	**28.1**	**31.1**	**31.6**	**29.5**	**28.1**	**26.1**	**28.8**	**30.4**	**28.2**	**26.9**	**25.0**	**27.6**
B/F	**34.6**	**31.9**	**30.5**	**28.3**	**31.3**	**31.8**	**29.7**	**28.3**	**26.3**	**29.0**	**30.8**	**28.4**	**27.1**	**25.2**	**27.9**
F/k	**34.8**	**32.1**	**30.8**	**28.5**	**31.6**	**31.9**	**29.9**	**28.6**	**26.5**	**29.2**	**30.9**	**28.5**	**27.4**	**25.4**	**28.1**
k/B/F	**35.2**	**32.4**	**30.9**	**28.6**	**31.8**	**32.3**	**30.2**	**28.7**	**26.4**	**29.4**	**31.2**	**28.8**	**27.5**	**25.4**	**28.2**
Mean	**33.5**	**30.9**	**29.4**	**27.3**		**31.0**	**28.8**	**27.3**	**25.4**		**29.6**	**27.5**	**26.2**	**24.3**	
L.S.D	**A**:1.82 **B**:1.89 **AB**:3.77					**A**:1.64 **B**:1.71 **AB**:3.43					**A**:1.53 **B**:1.58 **AB**:3.17				

Table (6): Effect of preharvest treatments on acidity % of Zebda mangoes during shelf life in 2021, 2022 and 2023 seasons

Season	2021					2022					2023				
T / D	0.0	5	10	15	M	0.0	5	10	15	M	0.0	5	10	15	M
Control	**0.61**	**0.57**	**0.53**	**0.49**	**0.55**	**0.68**	**0.63**	**0.58**	**0.54**	**0.61**	**0.71**	**0.66**	**0.61**	**0.56**	**0.64**
Boron (B)	**0.58**	**0.54**	**0.50**	**0.46**	**0.52**	**0.64**	**0.59**	**0.56**	**0.51**	**0.58**	**0.67**	**0.62**	**0.58**	**0.53**	**0.60**
Potassium citrate (K)	**0.58**	**0.54**	**0.51**	**0.46**	**0.52**	**0.64**	**0.58**	**0.57**	**0.51**	**0.58**	**0.67**	**0.61**	**0.61**	**0.53**	**0.61**
Fulvic (F)	**0.60**	**0.56**	**0.52**	**0.48**	**0.54**	**0.66**	**0.61**	**0.58**	**0.53**	**0.60**	**0.69**	**0.64**	**0.60**	**0.55**	**0.62**
B/k	**0.57**	**0.53**	**0.50**	**0.46**	**0.52**	**0.63**	**0.58**	**0.56**	**0.50**	**0.57**	**0.66**	**0.61**	**0.58**	**0.52**	**0.59**
B/F	**0.57**	**0.53**	**0.49**	**0.45**	**0.51**	**0.63**	**0.58**	**0.54**	**0.50**	**0.56**	**0.65**	**0.61**	**0.56**	**0.52**	**0.59**
F/k	**0.56**	**0.52**	**0.49**	**0.46**	**0.51**	**0.62**	**0.57**	**0.54**	**0.51**	**0.56**	**0.65**	**0.59**	**0.56**	**0.53**	**0.58**
k/B/F	**0.55**	**0.52**	**0.48**	**0.44**	**0.50**	**0.61**	**0.58**	**0.53**	**0.49**	**0.55**	**0.64**	**0.60**	**0.55**	**0.51**	**0.58**
Mean	**0.58**	**0.54**	**0.50**	**0.46**		**0.64**	**0.59**	**0.56**	**0.51**		**0.67**	**0.62**	**0.58**	**0.53**	
L.S.D	**A**:0.02 **B**:0.02 **AB**:0.04					**A**:0.03 **B**:0.03 **AB**:0.06					**A**:0.02 **B**:0.02 **AB**:0.04				

The variation in fruit characteristics depends on the coating type used where, use paraffin wax gave the least alter of fruit characteristics compared to the other treatments. The results indicated that using coating treatments proved effective in maintain properties and appearance of fruit that keeping the mango fruits for long period.

Discussion

Handling and storage is an important method for fruit production and its quality. Fresh weight loss and fruit decay percentage were increased by extending storage and shelf life duration. The loss of water from fruits during storage and shelf life is a substantial problem due to shrinkage and weight loss, thus, the fruits could be damaged and loss its quality **[25]** The fruit weight decreases due to its respiratory process, the transference of humidity and some processes of evaporation of moisture inside the fruits **[26]**

The loss of fresh fruits and vegetables weight is mainly due to the loss of water caused by transpiration and respiration processes. The increase of mango fruit weight loss during storage and shelf life may be due to the increase of the respiratory metabolism of the fruits and reduction the loss of water absorbed by treated the fruit surface **[27, 28, 29, 30]**

Losses in firmness with the progress of storage period due to ripening of mango fruits as a result of an increase in activities of cell wall hydrolysis enzymes such as pectinesterase, polygalacturonase pectin methylesterase and pectatelyases during ripening and cold storage **[31]** In the cell wall, hydrolyzing enzymes are enhanced by CO_2 production in climacteric fruits **[29, 32, 33, 34]**

Total soluble solids and sugar contents in mango fruits increased gradually with the increase of storage time. This significant increase in TSS and sugar contents could be due to the degradation in insoluble compounds present in date fruit**[35]**

With the addition of nutrients, such as K and B, growth and fruiting qualities may be favorable. As the most common cation in plants, potassium is necessary for both respiration and the metabolism of carbohydrates. It also plays a key role in the preservation of the ionic balance within cells by binding ionically to the enzyme pyruvate kinase **[36]**

Our findings also demonstrated that, in comparison to the control, the treatment of B and K resulted in improved growth features.

Potassium may improve photosynthetic synthesis and transport to fruit, which may be the reason for its beneficial effects on fruit. Additionally, because of the way that K interacts positively with other nutrients, particularly N, and with production methods, its impact on fruit quality may be indirect. Thus, adding potassium improved the quality and shelf life of mango fruit **[37, 38, 39]**

Moreover, citric acid chelating these free radicals and protecting plant from injury could result in prolonging shelf life of plant cells and enhancing growth characteristics **[40, 41]**

Our results also pointed out that foliar spraying with potassium and boron led to improve quality and shelf life of fruits**.**

Moreover, the important regulatory effect of boron in biosynthesis and translocation of sugars, activating metabolism enzymes, building of IAA, cell enlargement and division, water absorption and nutrient transport give other explanations **[42, 43]**

The positive effective of potassium in enhancing fruit might be due to its function in improving synthesis of photosynthesis and their transport to fruit. So, potassium application enhanced fruit quality of mango **[37, 38, 39, 44]**

CONCLUSION

This study illustrated that, spraying either of potassium citrate and boron or potassium citrate and boron plus fulvic acid are the promising strategy for keeping postharvest quality and increasing shelf life and marketing period of mangoes cv. 'Zebda' up to 15 days.

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تأثير الرش بالبوتاسيوم والبورون وحمض الفولفيك على الجودة
والعمر التسويقي لثمار مانجو الزبدة

الملخص

تمت دراسة تأثير الرش بالبوتاسيوم والبورون وحامض الفولفيك على الجودة والعمر التسويقي لثمار مانجو الزبدة خلال ثلاثة مواسم متتالية 2021، 2022 و2023. تم قطف الثمار ونقلها مباشرة إلى المعمل وغسلها وتجفيفها. تم عرض الثمار علي درجه الغرفه لمدة 15يوماً. تم أخذ عينات الثمار بدايه من فتره العرض وعلى فترات خمسة أيام خلال فترة الصلاحية لتقييم خصائص الثمار وفتره القابلية للعرض والتسويق.

أدي الرش بالبوتاسيوم والبورون وحمض الفولفيك إلى تقليل تدهور الخصائص الفيزيائية والكيميائية معنويا خلال فتره العرض والتسويق . علاوة على ذلك، أكدت هذه الدراسة أن المعاملات زادت بشكل فعال من فتره عرض وتسويق الثمار مقارنة بالثمار غير المعاملة (الكنترول).

أوضحت هذه الدراسة أن رش البوتاسيوم والبورون هي الإستراتيجية الواعدة للحفاظ على جودة ما بعد الحصاد وزيادة العمر التسويقي للمانجو. "الزبدة" حتى 15 يومًا.