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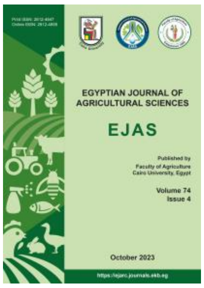

Improving Fruit Quality of Two Plum Cultivars Using Nutrients and Chitosan

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ABSTRACT

The main goal of this research is to solve the problem of the African Rose plum, including its poor quality and low sugar content, the problem of the lack of hardness in the Pioneer plum, the difficulty of handling it, and the short lifespan of the fruit after harvesting. To improve the quality of African Rose fruits and increase the hardness of Pioneer fruits, the following treatments were used; 1- Potassium boron 3 g/L, 2- Potassium boron 3 g/L + Calcium chloride 4 g/L + boric acid 1 g/L, 3- Potassium boron 3 g/ L + Potassium silicate 3 cm ^{3}/ L, 4- Potassium boron 3cm^{3} /L+ Chitosan (4%) 3 cm ^{3}/L, 5- Potassium silicate 3 cm ^{3}/ L, 6- Potassium silicate 3 cm/L + Chitosan (4%) 3 cm ^{3}/L. 7- Chitosan (4%)3 cm ^{3}/L, 8- Calcium chloride 4 g/ L, boric acid 1 g/L, 9- Calcium chloride 4 g/ L + Copper sulfate 0.8 g /L, 10- Calcium chloride 4 g /L+ Magnesium sulfate 1%, 11- Control. Yield/ tree, fruit attributes, fruit firmness (TSS and TA at zero time and after shelf life), and elements were assessed. T_9 was statistically the best treatment increased yield, fruit firmness at zero time and after shelf life, low decay fruits and fruit weight loss, highest leaves' calcium content, maximum Net profit at harvest on Pioneer and maximum net profit after shelf life for two weeks for African Rose and for one week for Pioneer. T_2 gave the highest significant fruit quality parameters.

Keywords: *Plums; African Rose; Pioneer; boron; potassium silicate; chitosan; copper sulfate; magnesium sulfate; fruit firmness; TSS; anthocyanin*

1. INTRODUCTION

Plum is one of the most beloved deciduous fruits in general and, specifically, stone fruits. Its crop is called the golden yield due to the high profits maintained by its cultivation. Plums (*Prunus Salicina* L.) are members of the Rosaceae family, native to China, domesticated in Japan 400 years ago and are mainly used for fresh consumption (Manganaris *et al.*., 2008). The total acreage of plums grown in Egypt increased gradually in the last decade to 6,833 feddans with total production 46,653 tones (Agriculture Statistics of Egypt, 2021). This increase is attributed to the introduction of new cultivars characterized by low chilling requirements and self-fertility such as African Rose and Pioneer. African Rose evolved in South Africa and was released in 2009. It has been introduced and grown under the Egyptian semi-arid conditions. It is characterized by firm fruit hardness, good fruit color, and abundant production (Hassan *et al.*, 2021). By time, some negative fruit quality attributes were detected such as small fruits (36.66 gm), low juice TSS (11.5%), high acidity (0.114%), and low total sugars (6.78%) according to Sayed *et al.* (2021).

Pioneer fruits a have supreme fruit quality with respect to attributes such as size, color

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total soluble solids and acidity. Yet, negative post-harvest attributes were detected, e.g. low shelf life (4.02 lb/inch^2), high percentage of decay (5.61%), reduced flavor quality (too low acidity, no aroma), high fruit weight loss (7.16 %) and poor favorable appearance like shriveling or bruising (Abd Elaziz *et al.,* 2017).

Numerous researchers worked on solving negative fruit quality in both cultivars using nutrients foliar treatments to solve the problem of poor quality of the African Rose plum variety, due to the small size of the fruits and the lack of sugars and dissolved solids. To overcome the problems of Pioneer, such as the lack of hardness of the fruits, the difficulty of handling, and to reduce loss and spoilage, spraying nutrients was used to improve the quality.

Potassium has a positive effect on the quality and quantity of the product. Potassium is an important nutrient for plant meristematic growth and physiological functions, including regulation of water and gas exchange in plants, protein synthesis, enzyme activation, photosynthesis and carbohydrate translocation in plants, obtaining high sugar content, full and uniform color, and high-quality fruit depends on an adequate potassium intake (Zhang *et al.*, 2018 and Kuzin and Solovchenko, 2021). It increases the amount of dry matter, improving the sugar/acid balance and ensuring early harvest (Sürücü and Küçükyumuk, 2023). Potassium has favorable effects on metabolism of nucleic acids, proteins, vitamins and growth substances. Potassium has a very vital role in the refulgence of biotic stresses which damage the plants, as it plays a key role in the synthesis of high-molecular-weight compounds such as proteins, starch, and cellulose, and reduces the collection of soluble sugars, organic acids, and amides on which pathogens feed (Hawkesford *et al.*, 2012). Potassium positively affects the density of fruit flesh, leading to lesser water loss during storage and lower degradation of acids in fruit (Kacar and Katkat 1999).

Foliar Calcium and Boron application before, or after harvest, can prevent physiological disorders, delay ripening, and increase the concentrations of both Ca and B in fruit tissues, which all improve fruit quality (Chaiprasart *et al.,* 2006 and Dong *et al.* 2009).

Calcium element builds and strengthens the cell wall structure and membranes in plants. In the cell wall, appears to serve as an intern molecular biding agent that stabilizes pectin-protein complex of the middle lamella. Cell wall membrane surrounds the cytoplasm of cell and helps in maintaining the structure and shape of the cell (Huang *et al.,* 2008). Calcium is also associated with reduced senescence and retardation of fruit softening (Elmer *et al.*, 2007). Its ability to enhance post-harvest fruit quality is well known. Softening is an important post-harvest process linked to texture modifications during ripening. In addition, fruit softening is associated with cell wall disassembly and pectin modification which involves changes to polygalacturonase (PG) and pectin methyl esterase (PME) synthesis and activity (Chuni *et al.,* 2010; Dong *et al.*, 2009 and Singh *et al.*, 2007). The beneficial effects of calcium applications to fruits on firmness of a wide range of prune species is documented (Alcaraz-Lopez *et al.,* 2003; Manganaris *et al.*, 2005 and Hafez and Haggag, 2007).

Boron promotes calcium absorption, is involved in the transport of calcium in the plant and determines the ratio of potassium and calcium in plant tissue. Ca and B are two of the most important elements for supporting plant structural integrity and the function of the plasma membrane (Corgrove, 2005 and Singh *et al.*, 2012). Boric acid application also increases fruit firmness, total soluble solids concentration, and total sugar concentration; while decreasing total acidity, weight loss percentage, and fruit rot in fruit crops (Hafez and Haggag, 2007; Thomidis and Exadaktylou, 2010). Boron can also reduce pitting disorder of fruits (Sharma and Singh, 2009). Boron is associated with the carbohydrates chemistry and reproductive system of the plant (Suman *et al.,* 2017). Foliar treatments of application of calcium and boron caused significant increase Ca and B content in fruit flesh of plum varieties but their effect on storage behavior was cultivar dependent (Plich and Wojcik, 2001). Foliar application of potassium and boron combination has a good effect on yield and fruit quality of "Florida Prince" peach trees (Mosa *et al.,* 2016).

Copper plays a major role in photosynthesis and increases sugar content in fruits (Saini and Saini, 2019). It acts as an essential cofactor for numerous proteins. While the definitive number of these so-called cuproproteins is unknown, they perform central functions in plant cells. As a micronutrient, a minimal amount of Cu is needed to ensure cellular functions. Cu is also an essential player in electron transport, Cu involvement of numerous proteins and Cu dependent activities in the properties is one of the major Cu-accumulation sites in plants: the cell wall (Printz *et al.,* 2016). Cu application helps in accelerating lignification in plants to develop plants central defense mechanism against fungal infestation (Marschner, 2011) reducing the incidence of fungal infection in most plant species via improving the lignin formation (Evans *et al.,* 2007). Also, through enhancing the cross-linking of cell wall components and thereby controlling fungal diseases (Brown *et al*., 1995). In addition, Cu as a fungicide may denature the spores and conidia of fungus, which subsequently stops spore germination (Montag *et al.,* 2006).

Magnesium (Mg), is a primary constituent of chlorophyll, which accounts for 15 to 20 percent of the total Mg content of plants (Bybordi and Shabanov, 2010). Mg, apart from being a structural constituent of the chlorophyll molecule which requires Mg, including the formation of chloroplasts, contributes to the structural stability of nucleic acids and membranes. Mg also acts as an activator or regulator of several kinases, ATPases, RUBP carboxylase/ oxygenase, and several other enzymes of carbohydrate metabolism (Cakmak and Kirkby, 2008). In addition, Mg-deficient leaves are reported to be highly photo sensitive, thus, an increase in light intensity causes severe chlorosis and photooxidation of thylakoid constituents of these leaves by generation of reactive oxygen species (ROS) (Hermans *et al.*, 2004 and Cakmak and Kirkby, 2008;). Foliar application of magnesium was found to increase yield and improves citrus fruit properties (Maksoud *et al.,* 2003; Boman, 2001 and Boman, 2002), grape (Bybordi and Shabanov, 2010). Ca and Mg combination is responsible for strengthening the bonds between epidermal and other fruit cells resulting in better strength and low cracking (Poovaiah, 1986).

Silicon (Si) is considered a quasi-essential element. It encourages antioxidant defense mechanism, enhances plant growth, yield, fruit quality, mitigates biotic and abiotic stresses, photosynthetic activity, improves K\Na ratio, stimulates some enzymes activity, as well as increases the soluble substances of xylem (Ma, 2004; Van-Bockhaven *et al.,* 2013; Meena *et al.,* 2014 and Pavanello *et al.,* 2022). Foliar spraying potassium silicate at 1000 ppm on Le-Cont pear trees increased fruit yield and quality (at harvest and after cold storage) and net income (Sayed *et al.,* 2022).

Chitosan is an N-acetylated derivative of the polysaccharide chitin. It is a natural polymer with a polycationic nature, which has numerous applications in agriculture. Many studies have shown the high potential of chitosan for preserving fresh fruits. Pre-harvest spraying with chitosan is highly feasible and has a beneficial effect on fruit quality attributes (Reddy *et al.*, 2000). Chitosan proved to be an effective coating reducing weight loss on longan fruit (Jiang and Li, 2001), or in combination with calcium chloride on peach (El-Badawy, 2012). Chitosan coatings act as barriers, thereby restricting water transfer and protecting fruit skin from mechanical injuries, as well as sealing small wounds and thus delaying dehydration (Ribeiro *et al.,* 2007). Pre-harvest application of calcium chloride at 2% and chitosan at 1% concentration proved to be effective in reducing weight loss, decay and maximum firmness and lengthening shelf life of “Early Swelling” peach (Gayed *et al.,* 2017).

Foliar spraying of these nutrients proved to be an attractive remedy especially in arid zones under low rainfall conditions where the lack of water in summer drastically restricts nutrient absorption by the tree. In many cases, aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al.,* 2006). Also, it increases absorption efficiency, reduces element loss and cost.

The aim of this research was to improve the detected negative quality attributes of the fruits of the African Rose as increasing the size, increasing the sugars, increasing the firmness of the fruits of the Pioneer, and prolonging their shelf life, their tolerance to handling and prolong their display in the market by spraying some nutrients.

2. MATERIALS AND METHODS

The present study was carried out during two consecutive seasons 2021and 2022 in a private orchard at El-Sadat region in El Monoufia governorate, Egypt on two plum cultivars *i,e*, African Rose and Pioneer budded on Mariana rootstock. At the beginning of the study trees were 6 years grown at 2-3 meters apart (700 trees /feddan) in Sandy soil under palmate training pattern (double horizontal pattern) with a drip irrigation system utilized, chosen trees for this study were of symmetric size and vigor. Same agricultural practices recommended by the Ministry of Agriculture in Egypt were applied to all considered trees. The following treatments were randomized on the selected trees in random complete blocks design with single tree plot replicated three times for each treatment and four shoots were selected on each replicate for measurements used to study their effect on some physical and chemical fruit traits:

2.1. Foliar treatments

The following foliar treatments were sprayed every 15 days starting from pit hardening until 15 days prior to harvest *i.e.* 4 times.

T1- Potassium boron 3 g/ L.

T2- Potassium boron 3g/L + Calcium chloride 4 g /L + boric acid 1 g/L.

T3- Potassium boron 3g/L + Potassium silicate 3cm ^{3}/ L.

T4- Potassium boron/ L + Chitosan (4%) 3cm ^{3} /L.

T5- Potassium silicate 3cm^3/ L

T6- Potassium silicate 3cm^3 /L+ Chitosan (4%) 3cm ^{3}/ L.

T7 - Chitosan (%4) 3cm^3/ L.

T8- Calcium chloride 4 g /L+ boric acid 1 g/L.

T9- Calcium chloride 4 g /L + Copper sulfate 0.8 g /l.

T10- Calcium chloride 4 g/L + Magnesium sulfate 1%.

T11- Control.

The following traits were assessed to indicate the efficiency of the adopted treatments:

2.2. Total yield/ tree (kg/ tree)

At harvest, fruit yield was calculated by multiplying number of fruits per tree x average of fruit weight.

2.3. Fruit characteristics

Twenty randomly harvested fruits per tree for each considered tree were examined to assess the following attributes

2.4. Physical attributes

Fruit weight (g), fruit volume (cm^3) fruit length (cm), fruit diameter (cm) and fruit firmness (Lb. /inch^2) by using a pressure tester (Advance Force Gorge RH13, UK) .

2.5. Chemical characteristics

Total soluble solids percentage (TSS %) were determined in fruit juice by using a hand refractometer (Portable Refractometer ATC) . Total acidity percentage (TA %) as malic acid was determined in fruit juice according to A.O.A.C. (1995), anthocyanin pigment (Rabino and Mancinell,1986), total sugar (Dubois *et al.*, 1956).

2.6. Fruit shelf life for one- and two-weeks

African Rose and Pioneer plum fruits were stored at room temperature and measurements of hardness, TSS, and acidity were taken.

2.7. Leaf nutritional status

After harvest samples of 50 mature leaves from the 5th and 6th leaves from the base on July 15th from each considered tree. Leaves were washed with tap water then with distilled water and oven dried at 50 $^{\circ}$C to constant weight, ground, digested with sulphoric acid and hydrogen peroxide for the determination of (N, P, K, Ca, Mg). Nitrogen percentage was estimated by microkjeldahl Gunning method (A.O.A.C, (1995). Phosphorus percentage was determined calorimetrically by hydroquinone method (Foster and Cornelia, 1967). Potassium percentage was estimated by flame photometer as Jackson (1973). Calcium and magnesium (%) by using Atomic Absorption Spectrophotometer, Pye Unican SP1900, According to Brandifeld and Spincer (1965).

2.8. Feasibility study

To assess the applicability of promising treatments the following simple feasibility study was carried out:

Cost/ feddan (LE)= Cost of sprayed material per one tree for 4 times x number of tree /feddan (700 tree).

Yield/ feddan (Ton) = Fruit yield kg/tree x No. of trees / feddan (700 tree).

Gros income/ feddan (LE) = Price of one ton in the farm * tree yield ton/ Feddan**.**

The price of one ton = the price at farm gate was 12000 and 15000 for both seasons respectively.

Net profit = Gros income (cost of treatment+ cost of remain horticultural practices)

Horticultural practices cost = 30000 and 45000 LE/feddan in both seasons respectively.

2.9. Statistical analysis

The experiment was arranged as a randomized complete blocks design with three replicates and each replicate consisted of one tree and the collected data were statistically analyzed according to Snedecor and Cochran (1990). Means of treatments were compared using least significant difference (LSD) test at $P < 0.5$.

3. RESULTS AND DISCUSSION

3.1. Effect of conducted treatments on yield per tree (kg/tree)

Table (1) clarifies the effect of conducted treatments on total yield. It is evident for the data that T_9 (calcium chloride + copper sulfate) induced the highest yield of all treatments for both cultivars also for both seasons. It amounted to19.26 and 20.94 kg /tree) for African Rose cv in both seasons respectively, and (24.40 and 25.69 kg/tree) for Pioneer cv in both seasons, respectively. Insignificant differences were attributed to effect of T_{10} (calcium chloride + magnesium sulfate) on African Rose (19.91 and 21.41kg /tree). Whereas, the lowest yield was achieved by control trees (12.81 and 12.69 kg /tree) in seasons for African Rose, and (18.68 kg /tree) and (17.37 kg /tree) for Pioneer.

These results agree with Gill *et al.*, (2012) as they reported that foliar with 0.6% copper sulfate on pear trees given the highest fruit yield when compared with untreated trees. Copper spray is critical to the final yields (Singh, *et al.*, 2013). This may be due to being a constituent of several proteins or enzymes that perform important biochemical functions (Singh, *et al.*, 2013). Copper plays an important role in the photosynthesis as it was involved in electron transport chain. So, the plants deficient in copper have less enzymatic activities, which results in low carbon fixation and hence show stunted growth and less yield (Ram and Bose, 2000).

The yield of African Rose trees was affected by the use of calcium + magnesium application, this finding agrees with El-Tanany, *et al.*, (2011) on Washington navel orange trees where a higher number of fruits/ tree and yield was due to calcium and magnesium spraying. The role of Ca is stopping the formation of abscission zone between fruit pedicles and bearing branches as well as regulating the activity of enzymes and photosynthesis, which lead to increased production (Mighani *et al.* 1995 and Jackman and Stanley, 1995). Ca also performs important functions in activation of a number of enzymes including cycle nucleotide phosphodiesterase, adenylate cyclase, membrane bound Ca+2 – ATPase, NAD-kinase and cytosolic Ca concentration is an obligate intracellular messenger coordinating responses to numerous developmental cues and environmental challenges (White and Broadly, 2003). In addition to the role of Mg apart from being a structural constituent of chlorophyll molecule which requires Mg, including the formation of chloroplasts (Byrdi and Shabanov, 2010). It contributes to the structural stability of nucleic acids and membranes; it also acts as activator or regulator of several kinases, ATPases, RUBP carboxylase/ oxygenase, and several other enzymes of carbohydrate metabolism (Cakmak and Kirkby, 2008). Also, Mg-deficient leaves are reported to be highly photo sensitive, so an increase in light intensity causes severe chlorosis and photooxidation of thylakoid constituents of these leaves by generation of reactive oxygen species (ROS) which leads to the destruction of

Table (1): Effect of treatments on yield (kg/tree) of African Rose and Pioneer.

Treatments	Cultivars			
	African Rose		Pioneer	
	2021	2022	2021	2022
T1	15.58 ef	16.3 c	22.74 bc	21.88 bc
T2	15.40 ef	11.03 f	19.85 fgh	20.19 ef
T3	18.77 abc	20.08 ab	23.67 ab	22.80 b
T4	17.55 bcd	19 b	21 def	21.51 cd
T5	17.04 cde	19.03 b	21.68 cde	20.82 de
T6	13.82 fg	14.43 de	21.90 cd	20.15 ef
T7	16.53 de	15.44 cd	22.33 c	19.56 fg
T8	13.35 g	12.64 f	19.67 gh	18.65 g
T9	**19.26 ab**	**20.94 a**	**24.40 a**	**25.69 a**
T10	**19.91 a**	**21.41 a**	20.56 efg	22.34 bc
T11	12.81 g	12.69 ef	18.68 h	17.37 h
LSD 0.05	1.78	1.77	1.31	1.04

cells and deterioration of production in trees suffering from mg deficiency (Hermans *et al.*, 2004; Cakmak and Kirkby, 2008). These cycles of calcium, either with magnesium or copper, have led to increased tree yields.

3.2. Effect of tested nutrients on fruit weight and volume

Results in Table (2) show the results of fruit weight and volume. It is clear that T_{10} (calcium chloride + magnesium sulfate) also induced the highest significant fruit weight and volume in African Rose cv. in the both seasons. In the contrast, treatment of control recorded the lowest value. For this cultivar so, for T_6 (potassium silicate + chitosan) resulted the highest pioneer fruit weight and volume for both seasons whereas, control resulted in the lowest values in the both seasons.

3.3. Effect of tested nutrients fruit length and diameter

As for the effect on both fruit length and diameter, data demonstrate that T_9 (calcium chloride + copper sulfate) resulted in better fruit length compared to the control, while T_{10} (Calcium chloride + Magnesium sulfate) gave the best fruit diameter compared to the control for the African Rose cultivar. The most effective treatment for best length and diameter of the Pioneer fruits was the T_6 (potassium silicate + chitosan) (Table 3).

These results agree with what researchers found; where spraying calcium and magnesium was found to improve fruit weight, volume, dimensions) of African Rose plums (Kabeel *et al.*, 2013) pears (Sajid *et al.*, 2022) citrus (Maksoud *et al.*, 2003; El-Tanany *et al.*, 2011) grapes (Bybordi and Shabanov, 2010). These results may be due to the physiological role of Mg apart from being a structural constituent of chlorophyll molecule (Bybordi and Shabanov, 2010) and also acting as activator or regulator of several kinases, ATPases, RUBP carboxylase/ oxygenase, and several other enzymes of carbohydrate metabolism (Cakmak and Kirkby, 2008). The important effects are necessary for cell growth and expansion. In addition to the role of Ca makes the membranes impermeable, maintaining cell turgor pressure, and thus intercellular fluid does not leak into the intercellular spaces which is important for the growth of plant tissues, cell division, and cell enlargement (Singh *et al.*, 2007 and Singh *et al.*, 2013). Cell division and elongation leads to an increase in the weight and final size of the fruits.

In these results, the Pioneer cv was more responsive to T_6 (potassium silicate + chitosan) in terms of increases of fruit quality attributes as fruit weight, size, length and diameter. This result agrees with Sayed *et al.* (2022) who reported that foliar sprays of potassium silicate at 1000 ppm on "Florida Prince" peach trees enhancing fruiting aspects, fruit quality. These results may be due to that potassium is centers of four physiological biochemical roles, enzyme activation, membrane transport process, anion neutralization and osmotic potential. Potassium is also important in the formation and functioning of proteins, fats, carbohydrates and chlorophyll and in maintaining the balance of salts and water in plant cells (Sajid *et al.*, 2022). The role of silicon is considered a quasi-essential element because of its benefits for enhancing plant growth, yield, fruit, quality, mitigation of biotic and abiotic stresses, photosynthetic activity, improving K/Na ratio, stimulate some enzymes activity, increasing the soluble substances of xylem and encourage antioxidant defense mechanism (Van-Bockhaven *et al.*, 2013). Chitosan also induces chitinase activity, and elicits phytoalexins and defense barriers in the host tissues, as well as the defense responses in several plant systems. Chitosan acts as an inhibitor of various enzymes, leading to delay fruit senescence (Gayed *et al.*, 2017). These combinations of potassium, silicon, and chitosan led to an increase in the size and dimensions of the fruits of the Pioneer cultivar.

3.4. Effect of conducted treatments on fruit firmness

From data of fruit firmness (Table 4), it is clear that T_9 (calcium chloride + copper sulfate) caused the highest significant firmness when compared with other treatments in the both seasons and for both cultivars recording for African Rose (17.15 and 19.19 lb\inch2) in 1st and 2nd season, respectively and for. Or Pioneer cv (11.41 and 14.13) in both seasons, respectively. In contrast, the control treatment gained the lowest value in both seasons.

3.5. Effect of tested nutrients on fruit TSS and sugar

Data of TSS % and sugars (Table 5) indicated that for African Rose and Pioneer cultivars, T_2 (potassium boron + calcium boron) achieved

Table (2): Effect of treatments on fruit weight (g) and volume (cm^3) of African Rose and Pioneer.

Treatments	African Rose				Pioneer			
	Fruit weight (g)		Fruit volume (cm^3)		Fruit weight (g)		Fruit volume (cm^3)	
	2021	2022	2021	2022	2021	2022	2021	2022
T1	63.95c	53.91d	65.32 bcd	53.75 e	74.5 d	72.11fg	72.90e	71.6 d
T2	60.54e	51.08d	59.59 e	51.17 e	75.34 d	75 d	75.85d	75.2 c
T3	62.39d	70.63a	62.53 de	70.75 a	82.21 b	80.79b	82.50b	79 b
T4	60.03e	66.48bc	61.23 e	68.75 ab	71.95 e	72.84ef	72.50e	72 d
T5	64.16bc	63 c	66.44 b	63.67 cd	69.50 f	64.83 i	69.37f	64.17g
T6	62.4 d	67.21ab	62.83 cde	65.83 bcd	**87.25 a**	**83.50 a**	**87.25a**	**86 a**
T7	65.35bc	66.72bc	66.12 bc	66.58 bc	78 c	69.83 h	78 c	67.5 f
T8	56.99 f	52.76 d	56.18 f	52.50 e	79 c	73.41 e	78.90c	75.2 c
T9	65.51 b	63.07 c	64.67 bcd	62.50 d	81.89 b	78 c	82.75b	72 d
T10	**70.25 a**	**70.79 a**	**71.17 a**	**70.83 a**	74.68 d	71.23 g	74.70d	70 e
T11	45.23 g	35.99 e	45.33 g	36 f	65.03 g	55.03 j	67.51g	55.5 h
LSD 0.05	1.41	3.8	3.39	3.78	1.43	1.17	1.21	1.31

Table (3): Effect of treatments on fruit length (cm) and diameter (cm) of African Rose and Pioneer.

Treatments	African Rose				Pioneer			
	Fruit length (cm)		Fruit diameter (cm)		Fruit length (cm)		Fruit diameter (cm)	
	2021	2022	2021	2022	2021	2022	2021	2022
T1	4.32 bc	4.137 e	4.53 de	4.19 e	5.05 cd	4.75ab	5.03bc	4.93abc
T2	4.30 bc	3.94 e	4.35 e	4.25 e	5.08 cd	4.44cd	5.13ab	5 abc
T3	4.50 b	4.74 ab	4.94 ab	5.01 abc	5.27abc	4.75ab	5 bc	4.87abc
T4	4.30 bc	4.68 ab	4.64 cd	4.99 abc	4.89 de	4.45cd	5.08ab	4.95abc
T5	4.79 a	4.43 c	4.92 ab	4.83 bc	5.09 cd	4.60bc	4.98bc	4.81bcd
T6	4.79 a	4.64 bc	4.77 bc	4.94 abc	**5.43 a**	**4.88 a**	**5.41 a**	**5.25 a**
T7	4.24 c	4.64 bc	4.79 bc	5.03 ab	5.11bcd	4.43 d	5.32ab	4.74bcd
T8	4.31 bc	4.17 d	4.69 cd	4.53 d	5.33abc	4.81 a	5.25ab	5.12 ab
T9	**4.96 a**	**4.88 a**	4.89 b	4.80 c	5.39 ab	4.82 a	5.12ab	4.67 cd
T10	4.82 a	4.63 bc	**5.09 a**	**5.12 a**	5.23abc	4.79 a	5.09ab	5.11 ab
T11	4.17 c	3.67 f	4.05 f	3.86 f	4.67 e	4.36 d	4.69 c	4.43 d
LSD 0.05	0.21	0.21	0.18	0.21	0.29	0.17	0.37	0.41

Table (4): Effect of treatments on fruit firmness at harvest (Ib/Inch^2) of African Rose and Pioneer.

Treatments	Cultivar			
	African Rose		Pioneer	
	2021	2022	2021	2022
T1	12.35 cd	8.33 i	8.52 g	10.07 e
T2	12.19 cd	8.63 hi	9.03 f	10.33 de
T3	11.97 cd	10.73 d	7.10 h	8.44 g
T4	12.93 c	9.51 f	10.39 b	10.76 cd
T5	12.33 d	14.97 c	10.19 bc	11.76 b
T6	12.44 cd	15.94 b	9.84 cd	10.43 de
T7	11.60 d	10.18 e	9.35 ef	9.56 f
T8	13.95 b	9.18 fg	9.58 de	11.01 c
T9	**17.15 a**	**19.19 a**	**11.41 a**	**14.13 a**
T10	14.17 b	9.03 gh	9.23 ef	11.11 c
T11	10.43 e	8.66 hi	7.27 h	8.08 g
LSD 0.05	1.01	0.47	0.41	0.44

Table (5): Effect of treatments on fruit TSS (%) and Total sugars (%) at harvest of African Rose and Pioneer.

Treatments	African Rose				Pioneer			
	TSS %		Total sugars (%)		TSS %		Total sugars (%)	
	2021	2022	2021	2022	2021	2022	2021	2022
T1	21.20 b	21.20 b	2.95 abc	2.32 b	21.25 c	21.65 c	2.84 bc	2.56 bc
T2	**21.75 a**	**22.50 a**	**3.31 a**	**2.60 a**	**22.5 a**	**23.99 a**	**3.16 a**	**2.83 a**
T3	21.40 b	20.75 bc	3.1 ab	2.15 bc	21 cd	20.75 d	2.36 f	1.95 e
T4	21.35 b	20.25 cd	3.1 ab	2 cd	20 e	19.75 e	2.10 g	2.35 cd
T5	20.35 c	19.35 ef	2.8 bc	1.90 d	21.88 b	21 d	3.01 ab	2.74 ab
T6	20.70 bc	18.25 g	2.65 bcd	2 cd	20.17 e	18.54 f	2.64 de	2.24 d
T7	17.70 e	19.75 de	2.56 cd	2.14 bcd	21.17 c	21.9 c	2.63 de	2.44 cd
T8	20.25 c	20.75 bc	2.56 cd	2.12 bcd	21.84 b	21.92 c	2.74cd	2.31 d
T9	19.20 d	18.40 g	2.71 bcd	1.54 e	20.5 de	19.3 e	2.72 cd	2.35 cd
T10	21.42 ab	21.30 b	3.25 a	2.61 a	22 ab	22.7 b	3.12 a	2.81 a
T11	18.03 e	18.50 fg	2.35 d	1.17 f	20.08 e	17.83 g	2.47 ef	1.85 e
LSD 0.05	0.34	0.89	0.42	0.25	0.53	0.64	0.18	0.24

Table (6): Effect of treatments on fruit firmness (lb/inch^2) of African Rose and Pioneer after shelf life.

Treatments	African Rose 1 week		African Rose 2 week		Pioneer 1 week	
	2021	2022	2021	2022	2021	2022
T1	9.80 def	6.33 h	7.06 de	4.96 j	7.38 d	7.46 e
T2	9.67 ef	6.66 h	6.95 de	5.25 i	8.32 c	8.71 c
T3	10.42 c	8.68 de	7.68 cd	7.32 e	6.48 e	6.87 f
T4	9.44 fg	8.41 e	6.70 e	7.053 f	8.73 bc	9.57 b
T5	9.94 de	13.37 c	7.80 c	12.40 c	8.67 bc	8.64 cd
T6	10.04 d	14.93 b	7.90 c	13.60 b	7.75 d	8.34 d
T7	9.12 g	9.06 d	6.35 e	7.71 d	8.48 bc	7.5 e
T8	11.43 b	7.92 fg	8.70 b	6.86 g	7.55 d	8.53 cd
T9	**14.65 a**	**16.75 a**	**11.93 a**	**15.93 a**	**9.34 a**	**10.23 a**
T10	11.65 b	8.28 ef	8.93 b	6.95 fg	8.92 ab	8.29 d
T11	7.93 h	7.76 g	5.19 f	6.26 h	5.63 f	6.05 g
LSD 0.05	0.37	0.42	0.73	0.19	0.51	0.36

the highest results with significant difference from other treatments in the both seasons. On the other hand, control had the lowest TSS % and Total sugars in both seasons.

Table (6) demonstrate the effect on adopted treatments on fruit firmness after one and two weeks at room temperature (shelf life). As for African Rose, T9 (calcium chloride + copper sulfate) was the best treatment that led to the least loss in fruit firmness after 1 week amounting to (14.65 and 16. 75 lb/inch^2) and 2 weeks recording (11.93 and 15. 93 lb/inch^2) in the both seasons respectively. While control treatment showed the highest loss of firmness which were resulting in softer fruits that were not easily handled. For African Rose control fruits firmness acquired at room temperature amounted to 7.93 and 5.19 lb\inch^2 after one and two weeks respectively in the first season. In the second season however, highest loss in firmness was due to T_1 (potassium boron) amounting to (6.33 and 4.96 lb\inch^2). Yet it is worth mentioning that differences from control were insignificant. With respect to Pioneer cv, the shelf-life experiment extended to one weak only as fruits were in state not suitable for further investigation. (6.33 and 4.96 lb\inch^2). T_9 (calcium chloride + copper sulfate) had the firmest fruit during shelf-life period in the 1 week also in the both seasons recorded (9.34 and 10.23 lb\inch^2) in the both seasons respectively. Control treatment had the softest fruits (5.63 and 6.05 lb\inch^2) compared to other treatments

TSS % of the African Rose cultivar attained the highest values due to T_2 (potassium boron + calcium boron) at room temperature after one and two weeks in the first season amounting (21.85 and 23%) respectively and for (23 and 23.75) in the second season. While the least values were for control treatment, they were (17.55 and 18.78) for first and second weeks in the first season and (18.55 and 19.65) in the second one. With respect to pioneer cv, as a general trend it can be, it is noted that as a general trend juice TSS % increased by increasing the shelf-life period in all treatments but in different proportion between them and this also means a decrease in the firmness of fruits also with increasing storage duration. With respect to Pioneer cv. Also, T_2 (potassium boron + calcium boron) recorded the highest percentages over at all treatments after one week (24.13 and 24.58%) in the two seasons, respectively. On the contrary, the lowest values for 1-week shelf-life period were for control treatment which recorded the value (21.13 and 19.18 %) in 1st and 2nd seasons, respectively and with significant differences from other treatments that gained intermediate values.

In this study, we detected a pronounced increase in the firmness of both cultivars as a result of spraying the calcium and copper treatment at harvest and during the shelf life. Fruit firmness is one of the most crucial factors in determining the post-harvest quality and physiology of fruits (Kirmani *et al.,* 2013). Ca treatment strongly reduces the activity of the enzymes polygalacturonase and α-galactosidase (Evangelista *et al.*, 2000), as well as delayed ripening, reduced respiration rate, and delayed fruit senescence. Also, Ca can help link the molecules of pectin-free carboxyl groups, which are a component of cell walls that makes cells stronger and prevents the deterioration of the middle lamella of the cell wall is perhaps the key step in ripening process that leads to the loss of cell integrity or firmness (Naradison *et al.*, 2006 and Gayed *et al.*, 2017). In addition, fruit firmness in pears was found to increase application copper sulfate at 0.8% compared to the control tree (Sajid *et al.*, 2022). Also, application of Cu improved the firmness in pear fruits by 9% (Bouazizi *et al.,* 2011). The afore mentioned effects are due to physiological roles of copper which plays important roles in the functioning of several enzymes and production of lignin, which gives physical strength to cell walls (Ram and Bose, 2000). Copper also has antagonistic effects against microorganisms, such as yeast and molds (Weaver *et al.*, 2010). Copper fertilization was reported to decrease the severity of some fungal and bacterial diseases. These physiological effects may explain the increase in firm texture with Ca and Cu combination treatment.

In our results, foliar spray of potassium boron + calcium boron (T_2) increased the TSS of the two cultivars after harvest and during shelf life. These results are also in favor with the findings of Shirzadeh and Kazemi (2011) on apple, Mahajan *et al.* (2008) on plum, Mimoun *et al.* (2008) on peach, Mahajan *et al.* (2005); Sajid *et al.* (2022) on pear and Patel *et al.* (2016) on mango fruits.

They all declared that improved TSS of fruits with foliar application of potassium might be due

Table (7): Effect of treatments on fruit TSS (%) of African Rose and Pioneer after shelf life.

Treatments	African Rose 1 week		African Rose 2 week		Pioneer 1 week	
	2021	2022	2021	2022	2021	2022
T1	21.65b	22.16ab	22.64ab	23.35 b	22.88 b	22.75c
T2	**21.85a**	**23 a**	**23 a**	**23.75 a**	**24.13 a**	**24.58a**
T3	21.23 c	21.20cd	22.40 b	22.33 d	21.9 c	21.75d
T4	21.32 c	21.35bc	22.53 b	22.75 c	21.38de	21 e
T5	19.72 f	19.50 e	20.93ef	20.55 f	23.25 b	22.13d
T6	21.25 c	19.10ef	21.94 c	20.55 f	21.77cd	19.63 f
T7	18.33g	20.40 d	19.53 g	21.41 e	22.25 c	22.88c
T8	20.75d	22bc	21.40 d	23.25 b	23 b	23.13c
T9	20.05 e	18.85ef	20.80 f	19.53 g	21.75cd	20.63e
T10	19.63 f	22.17ab	21.25de	23.58ab	23.25 b	23.63b
T11	17.55h	18.55 f	18.78 h	19.65 g	21.13 e	19.18g
LSD 0.05	0.17	0.89	0.42	0.33	0.51	0.46

to the fact that potassium enhanced the translocation of sugars from leaves to fruits that a specific Kþ channel may be linked to sugar unloading (Lacombe *et al.*, 2000 and Nava *et al.*, 2007). Potassium foliar application has an important role in nutrient translocation from source to sink which results in better quality produce having maximum quantity of TSS. In addition to foliar spray, Ca and B combination to increase TSS of fruits agree with Kabeel *et al.* (2013) on "Kelsey" plum trees.

Also, Dilmaghani *et al.* (2005) reported that there is a positive correlation between potassium and calcium and soluble solid content. In addition to the role of calcium and the role of boron which affects, at least 16 functions in plants such as, fruiting, cell division, water relationships and the movement of hormones, transport of sugars, synthesis of cell wall and its structures, lignification, metabolism of phenols, carbohydrates, IAA, RNA, regulates opening of stomata and imparts drought resistance to crops (Singh *et al.*, 2013). The combined physiological roles of these elements may play a role in increasing TSS of fruits.

3.6. Effect of tested nutrients on fruit acidity

Results in Tables (8 and 9) showed that the highest juice acidity at zero time and after shelf life one and two weeks was as a result of T_9 (calcium chloride + copper sulfate) compared to other treatments while the lowest was by T_2 (potassium boron + calcium boron) for both African Rose and Pioneer plum cultivars.

The higher acidity of the African Rose fruits compared to Pioneer, explains the longer shelf-life period of African Rose than Pioneer. Likewise, T_9 (calcium chloride + copper sulfate) increased the acidity of the fruits compared to the rest of the treatments and its effect on increasing the lifespan of the fruits (López-Vargas *et al.*, 2018). The fruit acidity decreases during the shelf-life period in both cultivars due to the fruits' consumption of organic acids during the respiration of the fruits (Famiani *et al.*, 2015).

3.7. Effect of tested nutrients on anthocyanin pigment

The results in Table (10) indicate an increase in the Anthocyanin pigment content of the fruits for the treatments at harvest and after shelf life for African Rose for two weeks and Pioneer for one week compared to the control. The best results were for the increase in the Anthocyanin pigment content of the fruits as a result of T_2 (potassium boron + calcium boron) treatment. These results agree with Solhjoo *et al.* (2017) who reported that spraying with Kand $CaCl_2$ in combinations significantly increased fruit sugar and Anthocyanin concentrations of 'Red Delicious' apples

3.8. Effect of tested nutrients on fruit decay and weight loss percentage

The results presented in Table (11) show that all treatments reduced decay weight loss percentages compared to the control. The lowest percentages of fruit decay and fruit weight loss was due to T9 (calcium chloride + copper sulfate), followed by T_6 (potassium silicate + chitosan) compared to the rest of the treatments and the control during shelf life of African Rose for two weeks and Pioneer for one week. These results agree with Kheder *et al.* (2019) on "Balady mandarin" indication reduction fruit decay and weight loss by using copper sulfate, in addition to the using of calcium chloride to prolong shelf life of mango fruits (Khaliq *et al.,* 2016).

3.9. Effect of tested nutrients on leaf minerals content

The results in Tables (12 and 13) show a least in the leaves nitrogen content all treatments compared to the control, which recorded the highest nitrogen content for both cultivars during two seasons of the study. Moreover, T_2 gave the highest potassium content in the leaves compared to the remaining treatments and the control, which gave the lowest potassium content in the leaves for both cultivars.

The higher nitrogen content may be one of the verifications for the shorter fruit life of Pioneer than African Rose this is due to N fertilizer can decrease fruit firmness (Hunsche and Ernani, 2003).

Table (8): Effect of treatments on fruit acidity (%) of African Rose at zero time and after 1 and 2 weeks for shelf life.

Treatments	African Rose at Zero time		African Rose after 1 Week		African Rose after 2Weeks	
	2021	2022	2021	2022	2021	2022
T1	2.13 g	2.32 e	1.83 cd	1.70 def	1.29 bcd	1.41 de
T2	1.79 j	1.94 g	1.36 f	1.55 f	0.84 e	1.18 e
T3	2.33 e	2.14 f	1.85 bcd	1.92 ef	1.41 abc	1.47 d
T4	1.96 i	2.11 f	1.70 de	1.92 ef	1.21 cd	1.42 de
T5	**2.42 b**	**2.59 c**	**1.98 abc**	**2.37 b**	**1.55 ab**	**2.01 b**
T6	2.28 f	2.61 b	1.96 abc	2.05 bcd	1.55 ab	1.43 de
T7	2 h	2.13 f	1.98 abc	1.94 cdef	1.03 abc	1.33 de
T8	**2.38 d**	**2.68 b**	**2 a**	**2.26 bc**	**1.50 4a**	**1.76 bc**
T9	**2.53 a**	**3.74 a**	**2 a**	**3.34 a**	**1.62 a**	**2.84 a**
T10	1.99 h	2.46 d	1.55 e	1.97 bcde	1.06 de	1.22 e
T11	**2.40 c**	2.49 cd	1.62 e	1.96 cde	1.50 ab	1.56 cd
LSD 0.05	0.17	0.12	0.15	0.4	0.29	0.29

Table (9): Effect of treatments on fruit acidity (%) of Pioneer at zero time and after 1 week shelf life.

Treatments	Pioneer zero time		Pioneer after 1Week	
	2021	2022	2021	2022
T1	1.55 g	1.78 abc	0.69 cd	0.54 e
T2	1.53 h	1.52 d	0.57 d	0.48 f
T3	1.58 f	1.72 c	0.66 cd	0.57 d
T4	1.61 e	1.68 c	0.74 bcd	0.59 d
T5	**1.73 d**	**1.87 a**	**0.80 abc**	**0.70 b**
T6	1.74 d	1.74 bc	0.71 cd	0.68 b
T7	1.78 c	1.84 ab	0.69 cd	0.61 c
T8	**1.80 b**	**1.86 a**	**0.91 ab**	**0.72 b**
T9	**1.90 a**	**1.89 a**	**0.98 a**	**0.78 a**
T10	1.54 gh	1.67 c	0.76 bc	0.60 c
T11	1.58 f	1.71 c	0.73 bcd	0.65 c
LSD 0.05	0.02	0.12	0.19	0.05

Table (10): Effect of treatments on fruit anthocyanin (Mg/100gm) at zero time and after shelf life of African Rose (after two weeks) and pioneer (after one weeks).

Treatments	African Rose at Zero time		African Rose after shelf life		Pioneer at Zero time		Pioneer after shelf life	
	2021	2022	2021	2022	2021	2022	2021	2022
T1	1.26 b	1.27 b	2.31 b	2.38 b	0.052 d	0.058 c	0.64 d	0.66 c
T2	**1.42 a**	**1.47 a**	**2.66 a**	**2.75 a**	**0.125 a**	**0.133 a**	**1.392 a**	**1.45 a**
T3	1.13 c	1.09g	1.72 c	1.71 e	0.096 b	0.095 b	1.20 b	1.19 b
T4	0.52 f	0.49 c	1.39 d	1.41 f	0.074 c	0.073 c	1.13 b	1.11b
T5	0.75e	0.71 e	1.92 c	1.89 d	0.074 c	0.071 c	0.767 c	0.73 c
T6	0.58 f	0.51 f	1.24 e	1.16 g	0.076 c	0.070 c	1.18 b	1.06 b
T7	0.59 f	0.66 e	1.12 e	1.27 g	0.035 e	0.037 e	0.60 d	0.62 c
T8	0.94 d	0.96 c	1.60 d	1.74 e	0.038 e	0.038 d	0.52 e	0.52 d
T9	0.22 g	0.21d	1.82 c	1.71 e	0.067 c	0.063 c	0.369 f	0.35 e
T10	0.97 d	0.90 d	1.83 c	2.03 c	0.039 e	0.035 d	0.66 d	0.67 c
T11	0.18 g	0.19 g	1.08 e	1.13 g	0.025 f	0.025 e	0.18 g	0.16 f
LSD 0.05	0.12	0.17	0.31	0.14	0.014	0.019	0.11	0.13

Table (11): Effect of treatments on fruit decay (%) and weight loss (%) after shelf life of African Rose (after two weeks) and pioneer (after one weeks).

Treatments	African Rose						Pioneer			
	Decay fruit after 1 week		Decay fruit after 2 weeks		Fruit weight loss		Decay fruit after 1 week		Fruit weight loss	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T1	36 f	33 e	51 f	55.75 e	12.53 g	11.88 f	50 d	63 d	6.54 f	6.20 g
T2	32 g	36 d	50.5 f	47 f	12.68 g	13.27 d	35 f	42 g	14 b	14.66 c
T3	48 c	50 c	63 c	65.5 d	14.24 d	12.80 e	70 b	80 b	12.75 c	11.45 e
T4	44 d	50 c	62 c	68 c	16.32 b	13.83 c	70 b	78 b	7.50 e	6.61 g
T5	14.5 h	17 g	36 g	28.5 h	10.70 h	13.75 c	50 d	57 e	11.02 d	14.84 c
T6	0 i	0 g	36.5 g	33 g	10.50 h	8.55 j	40 e	42 e	6.50 f	5.30 h
T7	61 b	60 b	70 b	78 b	15.62 c	15.25 b	50 d	56 e	7.25 e	15.25 b
T8	44 d	50 c	60 d	64 d	13.66 e	11.15 g	37 e	47 f	12.20 c	13.64 d
T9	0 i	0 g	35 h	20 i	**10.20 j**	**8.05 i**	25 g	31h	**5.80 g**	**4.50 j**
T10	39 e	50 c	58 e	67 c	13.10 f	10.63 h	60 c	66 c	7.93 e	10.86 f
T11	53a	64 a	77 a	80.5 a	25.80 a	18.03 a	75 a	84 a	16.29 a	17.70 a
LSD 0.05	2.5	2.9	1.5	2	0.55	0.47	3	2.4	0.68	0.75

Table (12): Effect of treatments on leave NPK, Ca and Mg content of African Rose.

Treatments	N %		P %		K%		Ca%		Mg %	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T1	2.29 c	2.37 f	0.32 c	0.37 de	1.73 b	1.75 b	1.35 ef	1.30 f	0.33 de	0.30 e
T2	2.05 d	2.67 b	0.37abc	0.41bcde	**1.84 a**	**1.79 a**	1.60 b-d	1.50 d	0.35 bcd	0.36 cd
T3	2.47 b	2.57 c	0.45abc	0.46 abc	1.77 b	1.73 b	1.50 cde	1.40 e	0.38 b	0.41 bc
T4	2.24 c	2.52 d	0.34 bc	0.38 cde	1.73 b	1.63 d	1.20 f	1.00 g	0.42 a	0.44 ab
T5	2.27 c	2.36 f	0.31 c	0.35 e	1.76 b	1.67 c	1.55 b-e	1.60 c	0.31 e	0.33 de
T6	2.08 d	2.44 e	0.33 c	0.39 cde	1.70 c	1.69 c	1.41 ef	1.50 d	0.34 cde	0.36 cd
T7	2.45 b	2.41 e	0.38abc	0.43 a-e	1.50 e	1.54 f	1.70 bcd	1.80 b	0.37 bc	0.40 bc
T8	2.29 c	2.60 c	0.48 ab	0.49 ab	1.55 d	1.59 e	1.8 ab	1.89 a	0.32 de	0.31 de
T9	2.01 d	2.31 g	0.42abc	0.45 a-d	1.57 d	1.51 g	**1.97 a**	**1.95 a**	0.37 bc	0.39 bc
T10	2.11 d	2.71 b	**0.51 a**	**0.51 a**	1.75 b	1.74 b	1.75 abc	1.80 b	**0.45 a**	**0.48 a**
T11	**2.61 a**	**2.76 a**	0.31 bc	0.35 e	1.31 f	1.49 g	1.45 def	1.60 c	0.37 bc	0.41 bc
LSD 0.05	0.12	0.04	0.15	0.08	0.06	0.03	0.25	0.08	0.03	0.05

Table (13): Effect of treatments on leave NPK, Ca and Mg content of Pioneer.

Treatments	N %		P %		K%		Ca%		Mg %	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T1	2.21 f	2.79 e	0.45 cd	0.43bcd	1.84 b	1.87 b	1.50 d	1.60 de	0.41 e	0.43 f
T2	2.44 d	2.93 c	0.48 cc	0.46abc	**2 a**	**1.95 a**	1.60 c	1.70 cd	0.44 de	0.46 e
T3	2.81 b	3.19 b	0.48 bc	0.46abc	1.88 b	1.86 b	1.70 b	1.80 bc	0.50 b	0.51 c
T4	2.86 b	3.17 b	0.38 f	0.36 e	1.89 b	1.87 b	1.30 f	1.40 f	0.52 ab	0.53 b
T5	2.62 c	2.99 c	0.41 ef	0.39 de	1.86 b	1.79 c	1.70b	1.80 bc	0.45 d	0.47 de
T6	2.31 e	2.41 f	0.47bcd	0.45abc	1.85 b	1.83 b	1.50 d	1.60 de	0.41 e	0.43 f
T7	2.65 c	2.97 c	0.49 ab	0.47 ab	1.71 d	1.76 c	1.30 f	1.50 ef	0.49 bc	0.51 c
T8	2.29 e	2.91 d	0.50 ab	0.48 ab	1.77 c	1.78 c	1.81 a	1.92 a	0.46 cd	0.47 de
T9	1.82 g	2.26 g	0.45 cd	0.41cde	1.71 d	1.74 c	**1.85 a**	**1.95 a**	0.49 bc	0.48 d
T10	2.67 c	2.94 c	**0.52 a**	**0.49 a**	1.78 c	1.84 b	1.70b	1.85 ab	**0.55 a**	**0.56 a**
T11	**2.93 a**	**3.28 a**	0.44 de	0.41cde	1.69 d	1.72 c	1.40 e	1.70 cd	0.50 b	0.51 c
LSD 0.05	0.06	0.08	0.04	0.05	0.05	0.07	0.08	0.14	0.03	0.02

The treatments led to an increase in the leaf content of elements compared to the control. The best treatment to increase the leaves' phosphorus and magnesium content was T_{10} (calcium chloride + magnesium sulfate). This result may be due to linear relationships between Ca concentration and Mg concentration commonly observed among angiosperm species (White *et al.*, 2018). While T_9 (calcium chloride + copper sulfate) was the best to increase the leaves' calcium content in the two cultivars during the two seasons (Tables 12 and 13). This may be due to the synergism between copper and calcium, and low calcium levels lead to toxicity from excess copper, which confirms the connection between them (Chatterjee and Nautiyal, 2001).

3.10. Effect of tested nutrients on net profit

In Tables (14 and 15), the treatments suggest an increase in the net profit compared to the control because of the increase in the amount of production per feddan. The best treatment to increase net profit was T_{10} (calcium chloride + magnesium sulfate) on the African Rose cultivar

Table (14): Feasibility study for treatment applied on African Rose plum in 2021 and 2022 seasons.

Treatments	Yield/fed. (Ton)		Total before discount		Cost/fed. (LE)		Total income (LE)		Net profit (LE)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T1	10906	11410	130872	171150	13440	13440	117432	157710	87432	112710
T2	10780	7721	129360	115815	17080	17080	112280	98735	82280	53735
T3	13139	14056	157668	210840	13160	13160	144508	197680	114508	152680
T4	12285	13300	147420	199500	18480	18480	128940	181020	98940	136020
T5	11928	13321	143136	199815	2520	2520	140616	197295	110616	152295
T6	9674	10101	116088	151515	7560	7560	108528	143955	78528	98955
T7	11571	10808	138852	162120	5040	5040	133812	157080	103812	112080
T8	9345	8848	112140	132720	3640	3640	108500	129080	78500	84080
T9	13482	14658	161784	219870	5880	5880	155904	213990	125904	168990
T10	**13937**	**14987**	167244	224805	5250	5250	161994	219555	**131994**	**174555**
T11	8967	8883	107604	133245	0	0	107604	133245	77604	88245

Table (15): Feasibility study for treatment applied on Pioneer plum in 2021 and 2022 seasons.

Treatments	Yield/fed. (Ton)		Total before discount		Cost/fed. (LE)		Total income (LE)		Net profit (LE)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T1	15918	15316	191016	229740	13440	13440	177576	216300	147576	171300
T2	13895	14133	166740	211995	17080	17080	149660	194915	119660	149915
T3	16569	15960	198828	239400	13160	13160	185668	226240	155668	181240
T4	14700	15057	176400	225855	18480	18480	157920	207375	127920	162375
T5	15176	14574	182112	218610	2520	2520	179592	216090	149592	171090
T6	15330	14105	183960	211575	7560	7560	176400	204015	146400	159015
T7	15631	13692	187572	205380	5040	5040	182532	200340	152532	155340
T8	13769	13055	165228	195825	3640	3640	161588	192185	131588	147185
T9	**17080**	**17983**	204960	269745	5880	5880	199080	263865	**169080**	**218865**
T10	14392	15638	172704	234570	5250	5250	167454	229320	137454	184320
T11	13076	12159	156912	182385	0	0	156912	182385	126912	137385

Table (16): Effect of treatments on net profit after shelf life of African Rose and Pioneer.

Treatments	Net profit after 1 week of African Rose		Net profit after 2 weeks of African Rose		Net profit after 1 week of Pioneer	
	2021	2022	2021	2022	2021	2022
T1	55957	75516	42842	49874	73788	63381
T2	55950	34390	40729	28480	77779	86951
T3	59544	76340	42368	52675	46700	36248
T4	55406	68010	37597	43526	38376	35723
T5	94577	1264045	70794	108891	74796	73569
T6	78528	98955	49865	66300	87840	92229
T7	40487	44832	31144	24658	76266	68350
T8	43960	42040	31400	30269	82900	78008
T9	**125904**	**168990**	**81838**	**135192**	**126810**	**151017**
T10	80516	87278	55437	57603	54982	62669
T11	36474	31768	17849	17208	31728	21982

as a result of increasing productivity. While the best net profit result from the treatment was T_9 (calcium chloride + copper sulfate) for the Pioneer cultivar best net profit result from the treatment was T_9 (calcium chloride + copper sulfate) for the Pioneer cultivar.

3.11. Effect of tested nutrients on net profit after shelf life

Data in Table (16) demonstrate that all treatments showed an increase in net profit after shelf life for two weeks for African Rose and for one week for Pioneer compared to the control. The best treatment to increase net profit was T_9 (calcium chloride + copper sulfate) as a result of reducing decayed fruits during the shelf-life period for the two varieties during the two study seasons.

Conclusion

The results concluded that using foliar spraying of calcium chloride 4g/L + copper sulfate 0.8g /L four time between each spray and other 15 days starting from the pit hardening stage and the final one was two weeks before the harvest, led to a longer shelf-life period of two weeks for the African Rose cultivar and a week for the Pioneer cultivar and an increase in the net profit per feddan for the two varieties at harvest and after the shelf-life period for both cultivars. also, foliar spray of potassium boron + calcium boron (Potassium boron 3g/L + calcium chloride 4g/L + boric acid 1g/L) led to the best treatments for increasing TSS, sugars and Anthocyanin for African Rose fruits.

Authors' contributions

All authors contributed in conceptualization, methodology, software, validation, formal analysis investigation, resources, data curtain, writing the original draft preparation, writing, review, editing, supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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تحسين جودة ثمار صنفين برقوق باستعمال المغذيات والكيتوزان

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ملخص

الهدف الرئيسي من البحث هو حل مشكلة رداءة صفات الجودة وقلة نسبة السكريات للبرقوق الأفريكان روز، ومشكلة قلة الصلابة وصعوبة التداول وقلة فترة حياة ثمار البرقوق البيونير بعد الحصاد. ولزيادة جودة ثمار الافريكان روز وزيادة صلابة ثمار البيونير تم استخدام المعلملات التالية: 1- البوتاسيوم بورون 3 جم/لتر. 2- البوتاسيوم بورون 3 جم/لتر + كلوريد الكالسيوم 4 جم/لتر + حمض البوريك 1 جم/لتر. 3- البوتاسيوم بورون 3 جم / لتر + سيليكات البوتاسيوم 3 سم 3 / لتر. 4 – بورون البوتاسيوم 3 سم 3 / لتر + شيتوزان (4%) 3 سم 3 / لتر.5 – سيليكات البوتاسيوم 3 سم 3 / لتر. 6- سيليكات البوتاسيوم 3 سم / لتر + شيتوزان (4%) 3 سم3 / لتر. 7- شيتوزان (4%) 3سم3/لتر. 8- كلوريد الكالسيوم 4 جم / لتر . حمض البوريك 1 جم / لتر . 9- كلوريد الكالسيوم 4 جم / لتر + كبريتات النحاس 0.8 جم / لتر . 10- كلوريد الكالسيوم 4 جم / لتر + كبريتات المغنسيوم 1%. 11- الكنترول. تم تقييم المحصول / الشجرة وصفات الثمار (صلابة الثمار TSS و الحموضة عند الجمع وبعد فترة عرض الثمار على الرف) والعناصر. أدت معاملة كبريتات النحاس 0.8 جم / لتر(T9) لزيادة المحصول وصلابة الثمار عند الجمع وبعد فترة عرض الثمار على الرف ، وانخفاض تلف الثمار وفقد وزن الثمار، وارتفاع محتوى الكالسيوم في الأوراق، وأعلى صافي ربح عند الحصاد للبايونير وبعد عض الثمار لمدة اسبوع وأعلى صافي ربح للافريكان روز عند الجمع بعد عرض الثمار لمدة أسبوعين.وادت المعاملة بالبوتاسيوم بورون 3 جم/لتر + كلوريد الكالسيوم 4 جم/لتر + حمض البوريك 1 جم/لتر(T2) افضل صفات الجودة لثمار الافريكان روز.

المجلة المصرية للعلوم الزراعية المجلد (74)العدد الرابع (أكتوبر 2023) : 85-104.