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Effect of Foliar Application with Multi-Micronutrients and Polyamines on Productivity and Storeability of Valencia Oranges

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ABSTRACT

The present study was carried out during two successive seasons 2015 and 2016 on of Valencia orange trees (*Citrus sinensis* L. Osbeck) budded on Volkamer lemon (*Citrus volkameriana* L.) rootstock, grown in sandy soil under drip irrigation system, in a citrus orchard located in El-Kwamel farm, college of Agriculture, Sohag University, Egypt. The selected trees (33 tree) of Valencia orange cv. were set as a randomized complete block design (RCBD) with 3 replications. The target of this study was to investigate the effect of foliar spraying of multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe) and three levels of putruscine (10-3, 10-5 and 10-7mM/Lit) individually or their combinations at full bloom and after ten days from fruit set on productivity and some quality parameters upon harvest as well as during storage at room (ambient) temperature for better marketability of Valencia orange without economical loss. It can be concluded that 10-3mM/Lit (PUT) + Multi-micronutrients treatment gave the highest values of fruit set, retained fruit/tree, fruit weight (g), fruit juice weight (g), fruit juice volume (cm) and fruit peel thickness (mm) of Valencia orange. As well as it gave the highest rate of total soluble solids (TSS) percentage, TSS/acid ratio and ascorbic acid (100g juice) and the lowest values of fruit decay percentage during storage period. This study suggested that 10-3mM/Lit (PUT) + Multi-micronutrients treatment may be consider a useful technology for improve productivity and some quality parameters upon harvest of Valencia orange trees. As well as, the same treatments to avoid the negative quality effects during fruit storage at room (ambient) temperature especially increase the rate of total soluble solids percentage, TSS/acid ratio and ascorbic acid (100g juice) for better marketability of Valencia orange fruits without economical loss.

Keywords: Valencia orange, Putruscine, Multi-micronutrient, Foliar spraying, Fruit storage.

INTRODUCTION

Citrus is a member of world's subtropical fruits and Rutaceae family. The importance of citrus fruits in order of high vitamin C and anti-cancer effects (Martí *et al.*, 2007). Oranges are second fruit after apple that people consumed in all over the world.

Valencia orange trees grown at the new reclaimed soils such as sandy soil which is usually poor in their nutrients content, low organic matter and lower in catching water, with high nutrients leaching losses led to lower nutrient uptake by plant and has negative effect on vegetative growth, yield and fruit quality. Therefore, trees grown in this soil needs more attention in cultural practices such as fertilization, foliar spray with minerals and bio-fertilizers to enhance growth, yield and fruit quality. Foliar application of micronutrients like Zn, Cu, Mn, B and Fe has advantages over soil application because of high effectiveness, rapid plant response, convenience and elimination of toxicity symptoms brought about by excessive soil accumulation of such nutrients (Obreza *et al.*, 2010).

Micronutrient plays many complex roles in plant nutrition and plant production, while most of micronutrients participate in the functioning of number of enzyme systems, there is considerable variation in the specific functions of the micronutrients in plant and microbial growth processes, Micro-nutrients such as iron, zinc and boron are essential for different biological functions that might be attributed to tree yield and fruit quality (Shoeib, 2003). It is also increased resistance to disease and insect pests and improved drought tolerance (Tariq *et al.*, 2007).

Boron as a micronutrient plays significant role in growth and productivity of citrus. It increases pollen grains germination, pollen tube elongation, consequently, fruit set % and total yield, cell division, biosynthesis and translocation of sugars water and nutrient uptake (Garcia-Papi and Martinez, 2003, Abd-Allah, 2006 and Ahmad *et al.,* 2009). The Boron deficiency is mainly found in acidic and sandy soils, and those with low soil organic matter. Plant species differ dramatically in B mobility, and may be classified into species with restricted B mobility and those in which B is highly mobile (Brown and Shelp, 1997).

Also, zinc is another important microelement essential for plants due to its involvement in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis. Zn is required for the activity of various enzymes, such as dehydrogenases, aldolases, isomerases, transphosphorylases, RNA and DNA polymerases (Swietlik, 1999). It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Marschner, 1996, Badu and Singh, 2001, Mengel *et al.,* 2001, Dickinson *et al.,* 2003, Alloway, 2008 and Hassan *et al.,* 2010). However, in the light of better fruit quality development, Zn holds more significance besides imparting sustainability in production/ productivity by reducing the fruit drop (Malik *et al.*, 1999), and granulation (Kaur *et al.*, 1990).

Free polyamines (PAs) such as putrescine (Put), spermine (Spm) and spermidine (Spd) are polycationic compounds of low molecular weight that have been shown to play an important role as growth regulators in different stages of growth and development of buds, flowers and fruits in citrus, grapes and plum trees (Tiburcio, 1997, Eskandari, 1999 and Tonon *et al*., 2004).

Dibble *et al.* (1988) stated that deterioration of fruit quality physiologically correlates with reduction of polyamine (PA) content in the ripening fruits and increase in ethylene production. Polyamines are biological compounds of low molecular weight in their free forms which act as anti-senescent agents, delay ethylene production, reduce rate of respiration, increase fruit firmness, induce mechanical resistance, reduce chilling symptoms and retard colour changes (Valero *et al.*, 2002). It has been shown that during post-harvest life of several fruits, PAs reduced fruit softness, fruit colour, physiological weight loss and delaying ripening (Malik *et al.*, 2003, Malik and Singh, 2005, Aman and Zora, 2006, Jawandha *et al.*, 2012 and Mohammad *et al.*, 2013).

With due attention to an importance of citrus as one of the most important horticulture and exports crops of Egypt and in order to increase shelf life and quality improvement of citrus, research in this field is necessary therefore, the present study aimed to investigate the effect of foliar spraying of multi-micronutrient (iron, zinc and boron) and polyamine (Putrescine) individually or their combinations during full bloom and after ten days from fruit set on leaf mineral content, productivity, some quality parameters upon harvest as well as during storage at room (ambient) temperature for better marketability of Valencia orange fruits without economical loss.

MATERIALS AND METHODS

The present study was carried out during two successive seasons 2015 and 2016 on 10- years old Valencia orange trees (*Citrus sinensis* L. Osbeck) budded on Volkamer lemon (*Citrus volkameriana* L.) rootstock, grown in sandy soil and spaced 5 x 5 m apart subjected to drip irrigation system, in a citrus orchard located in El-Kwamel farm, college of Agriculture, Sohag University, Egypt, is subject to mild winters and warm and dry summer. All the chosen trees healthy, nearly uniform in shape and size and received the same horticulture practices.

Table 1. Analysis of orchard experimental soil at El-Kwamel Farm, College of Agriculture, Sohag University, Egypt.

Physical properties	**Sand**	**Silt**	**Clay**	**$CaCo_3$ (%)**	**O.M (%)**	**Texture**
	89.60	5.85	4.55	3.10	0.07	Sandy
Chemical composition	pH	EC dSm-1	N%	P ppm	K ppm	SO_4 meq/L
	8.70	1.20	0.05	0.80	185.0	3.90
	Na meq/L	K meq/L	Ca meq/L	Mg meq/L	Cl meq/L	Hco_3 meq/L
	0.54	0.37	8.62	3.28	6.00	3.00

Climatic factors data: Mean monthly temperature and relative humidity (maximum and minimum) for El-Kwamel region (farm location) during 2014, 2015 and 2016 seasons (according to Metrology Organization in Cairo) are shown in figure (1).

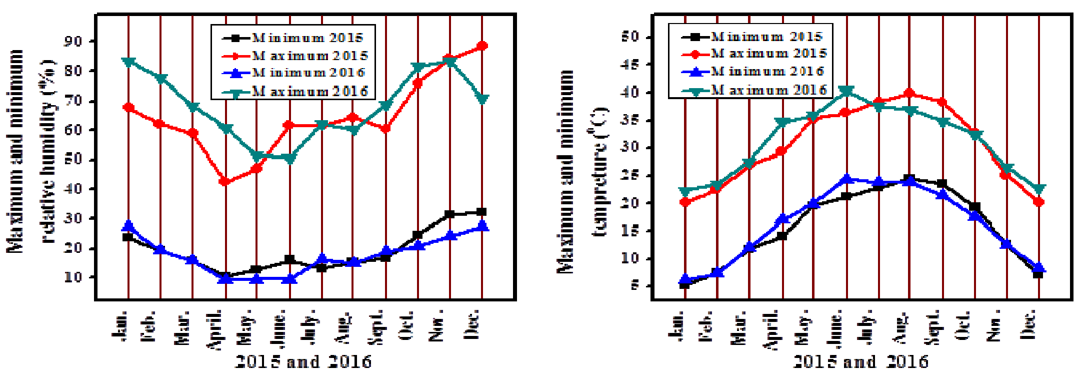

Figure 1. Meteorological data (mean monthly maximum and minimum temperature and relative humidity) for 2015 and 2016 under Sohag climatic conditions.

Experimental work: To improve productivity and storability of Valencia orange trees, multi-micronutrient i.e., boron (B) as liquid borost 15%, zinc (Zn) as microgreenchelat zinc 15% and iron (Fe) as strong chelat iron 12% (1% B, 200 ppm Zn and 250 ppm Fe**)** and three levels of putruscine (PUT) "1,4- Diaminobutane, molocular weight 88.15 and linear formula NH_2 (CH_2) NH_2" (10^{-3}, 10^{-5} and 10^{-7}mM/Lit) were sprayed either alone or in combinations on Valencia orange trees (30 tree) with (3 tree) control (water spray)during full bloom stage or after ten days from fruit set in early morning,during each season. All treatments were applied to run off by using compression sprayers (5L solution/tree) at the previously mentioned times. Wetting agent Tween 20 (1%) was added to all treatments to reduce the surface tension and increase the contact angle of sprayed droplets.

Treatments: The details of the treatments composition were as follow:

(T_1) Control (water spray)

(T2) Spraying multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe) once at full bloom stage.

(T3, T4 and T5) Spraying 10-3 mM/Lit (PUT), spraying 10-5 mM/Lit (PUT) and spraying 10-7 mM/Lit (PUT), once at full bloom stage.

(T6, T7 and T8) Spraying 10-3 mM/Lit (PUT) + multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe), spraying 10-5 mM/Lit (PUT) + multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe) and spraying 10-7 mM/Lit (PUT) + multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe) once at full bloom stage.

(T9, T10 and T11) Spraying 10-3 mM/Lit (PUT) + multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe), spraying 10-5 mM/Lit (PUT) + multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe) and spraying 10-7 mM/Lit (PUT) + multi-micronutrients (1% B, 200 ppm Zn and 250 ppm Fe) once at full bloom and after ten days from fruit set stage.

Experimental design:

33 tree of Valencia orange cv. Were selected and set as a randomized complete block design (RCBD) with 3 replicates for analyses. During storage, the three replicates

represented by 5 fruits for each treatment and taken to assess their quality parameters.

Data were recorded for the following parameters:

1. Productivity:

a. Fruit set and retention percentage: Ten shoots one-year-old per each-tree (replicate) were selected and tagged at random, total number of flowers per shoot was counted at full bloom and fruit set was counted after one month from full bloom stage. The average number of fruits per shoot were recorded at the time of harvesting and calculated as percentages. Percent fruit set (FS %) and fruit retention (FR %) were calculated by the following formula:

$$\text{F.S. (\%)} = \frac{\text{Number of fruitlets/shoot at set time}}{\text{Number of flowers/shoot at full bloom}} \times 100$$

$$\text{F. R. (\%)} = \frac{\text{Number of fruits at harvesting period}}{\text{Number of fruitlets at time of set}} \times 100$$

b. Fruit yield (Kg/tree): The total yield per tree (kg) was obtained at harvest period when the fruits reached a peak in peel color and TSS in the control treatment reached 10.3% to 11.0% (Bai *et al.,* 2009), fruits were picked from all treated trees on 9th and 5th December 2015 and 2016 seasons, respectively, fruits per tree were counted and weighted to estimate the yield/ tree (kg).

c. Fruit yield increase or decrease (%): Fruit yield increment or reduction was calculated as percentage through the following equation:

- fruit yield (kg)/control

Fruit yield increment or reduction (%) =

$$\frac{\text{Fruit yield (kg)/treatment}}{\text{ruit yield (kg)/control}} \times 100$$

2. Fruits quality:

At harvest time, five fruits from each selected tree (replicate) were chosen randomly to determine the following physic-chemical traits which included fruit weight (g), fruit peel thickness (cm), fruit Juice volume (cm), fruit total soluble solids percentage (TSS%), fruit TSS/acid ratio and fruit ascorbic acid (100g juice) content upon harvest. Enough number of fruits from each replicate were harvested, packed in cardboard boxes. They were sorted out for shape, size, and color intensity and stored at room (ambient) temperature (20 ± 2 °C and 85 ± 2% R. H.) for 21 days. The analyses were performed to determine fruit quality which included fruit weight loss (%), fruit decay (%), TSS (%) ,TSS/acid ratio and Ascorbic acid (100g juice)every seven days up to end of the storage periods.

a. Fruit physical characteristics:

1. **Fruit weight (g):** It was determined by weighting the fresh fruit samples (15 fruit) and the average fruit weight were recorded in (g.).
2. **Peel thickness (mm):** Peel thickness of five fruits per replicate were measured using Averner Caliper and the averages were recorded in millimeters.
3. **Fruit Juice volume (ml):**Selected fruit were peeled by hand in the laboratory, then, the average of fruit Juice volume (ml) were calculated.
4. **Fruit weight loss:** In order to determine fruit weight (FW) loss during the storage period, five fruit from each replicate were separated at the beginning of storage and weighed. Fruit weight loss was then measured weekly through the following equation:

Fruit weight loss (%) =

$$\frac{\text{F.W. before storage – F.W. after storage}}{\text{F.W. before storage}} \times 100$$

Weight loss for each replicate and each treatment was calculated as percentage.

5. **Fruit decay percentage:**Unmarketable fruits including pathological or physiological disorders were counted and relative to the initial number of fruits per each sample and calculated as a percentage for each replicate and treatment too through the following equation:

Fruit weight loss (%) =

$$\frac{\text{Number of decayed fruits at the time of sampling}}{\text{Initial number of fruits}} \times 100$$

b. Fruit chemical content:

1. **Total soluble solids percentage (TSS %):** Total soluble solids (TSS %) was measured in the juice by using handy refractometer. Total acidity was determined by titration with Na OH at 0.1 N and phenolphthalein as an indicator, and then expressed as gram citric acid/ 100 ml juice, according to A.O.A.C. (1985).
2. **TSS/acid ratio:** TSS/acid ratio was estimated mathematically by dividing the value of TSS by titrable acidity.
3. **Ascorbic acid (V.C) mg/100g juice):** Ascorbic acid content (mg/100 ml juice) was determined according to the method given in A.O.A.C. (2000).

Statistical analysis:

All data collected were subjected to statistical analysis of variance (ANOVA) and significant difference among means was determined according to (Snedecor and Cochran, 1972). In addition significant difference among means were distinguished according to the Duncan's, multiple test range (Duncan, 1955) whereas, capital and small letters were used for differentiating the values of specific and interaction effects of investigated factors, respectively.

RESULTS AND DISCUSSION

1. Effect of multi-micronutrient and putruscine application alone or in combination at different concentrations on productivity:

a- Fruit set and fruit retention (%):

Concerning the fruit set percentage data preformed that, there were insignificant differences between all treatments with respect to the fruit set percentage in the first season. While in the second season multi-micronutrient, putrescine and putrescine plus Multi-micronutrient treatments significantly increased the fruit set percentage more than that of control. The highest fruit set percentage in both seasons were recorded for 10-7 mM/Lit (PUT) + Multi-micronutrient treatment with percentages (100.00 and 100.00) in both season, respectively Table (2).

Similar results were proved by Harhash and Abdel-Nasser (2001), Jeyakumar *et al.* (2001), Slavki *et al.* (2001) and Sarrwy *et al.* (2012) they stated that using boron was very beneficial in stimulating fruit setting in citrus and other fruit crops. Also, Hafez and El-Metwally (2007) found that Zn treatments promote fruit set in Washington navel orange. Likewise, Tariq *et al.*, (2007) Khan *et al.* (2012) and Baghdady *et al.* (2014) indicated that foliar spraying of with Chelated zinc and boron significantly increased fruit set % in citrus and other fruit crops. Furthermore, Sajid *et al.*, (2010) concluded that % fruit set was not significantly affected by foliar spray of Zn and B alone or either in combination in sweet orange. In addition, Bioniel and Protacio (2002), Malik and Singh (2006) and Abd El-Migeed *et al.*, (2013) found that increases in fruit set have been obtained with polyamines (putrescine) in citrus and other fruit crops.

Table 2. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on percentage of fruit set and retention of Valencia oranges during 2015 and 2016 growing seasons.

Treatments	Fruit set (%)		Fruit retention (%)	
	2015	2016	2015	2016
Control	90.69^{A}	83.70^{A}	85.40^{A}	64.40^{B}
Multi-micronutrient	87.38^{ABC}	65.67^{AB}	50.98^{A}	74.47^{B}
10^{-3} m M/Lit (PUT)	76.77^{BC}	72.25^{AB}	55.95^{A}	74.73^{B}
10^{-5}mM/Lit (PUT)	86.60^{ABC}	81.10^{AB}	46.76^{A}	71.55^{B}
10^{-7}mM/Lit (PUT)	79.50^{ABC}	75.19^{AB}	77.55^{A}	94.01^{AB}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	81.65^{ABC}	74.81^{AB}	90.18^{A}	95.0^{A}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	82.19^{ABC}	72.54^{AB}	57.68^{A}	70.65^{B}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	75.79^{C}	56.82^{B}	65.8^{A}	88.33^{B}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	88.29^{ABC}	78.58^{AB}	43.04^{A}	50.94^{B}
10^{-10}mM/Lit (PUT) + Multi-micronutrient	90.36^{AB}	81.43^{AB}	53.47^{A}	70.94^{B}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	83.49^{ABC}	81.42^{AB}	57.27^{A}	63.53^{B}

Mean separation within treatments of the Valencia oranges according to L.S.D. at 0.05 level.

In regard to the fruit retention percentage data preformed that, there were insignificant differences between all treatments in the first season with respect to fruit number/tree. Whereas, in the second season 10^{-3}mM/Lit (PUT) + Multi-micronutrient treatment significantly increased the fruit retention percentage more than that of other treatments. The trees were treated with 10^{-3}mM/Lit (PUT) + Multi-micronutrient foliar spray resulted in the maximum increase in retained fruit/tree (90.18 and 95.0) in both seasons, respectively, compared with other treatments including the control.

These results are in accordance with those reported by Hafez and El-Metwally (2007), Tariq *et al.* (2007), Khan *et al*. (2012), Sarrwy *et al.* (2012) and Yadav *et al.*(2013) they proved that foliar spraying with micronutrients have important role in fruit retention in citrus and other fruit crops. Besides, Singh and Janes (2000), Bioniel and Protacio (2002), Malik and Singh (2006), Kassem *et al.* (2011) and Abd El-Migeed *et al.* (2013) indicated that exogenous application of polyamine improved fruit retention in citrus and other fruit crops.

b. Yield (Kg/tree) and yield increase or decrease (%).

Concerning the Yield (Kg/tree) data preformed that, there were significant differences between different treatments with respect to the yield (Kg/tree) in both seasons. The highest values achieved by 10^{-3}mM/Lit (PUT) + Multi-micronutrient treatment with (32.77 and 35.36 Kg/tree) in both seasons, respectively as shown in Table (3).

These results were coincide with those obtained by Dawood*et al.* (2000), Ram and Bose (2000), EL-Baz (2003), Hafez and El-Metwally (2007), Tariq *et al.* (2007), Abd El-Motty*et al.*(2010), Sajid *et al.* (2010), Hanafy Ahmed *et al.* (2012), Kazi*et al.* (2012), Khan *et al*. (2012), Sarrwy *et al.*(2012), Yadav *et al.* (2013), Abd El-Motty and Orabi (2014), Ashraf *et al.* (2014), Baghdady*et al.*(2014) Salama (2015),Sayyad-Amin *et al.* (2015)) and Gurung *et al.* (2016). They concluded that foliar spraying of micronutrients (boron and zinc) increased the yield and the combined spraying of them was most effective in improving the fruit yield / tree in citrus and other fruit crops. In addition, Ashraf *et al.* (2014) indicated that application of zinc improves the citrus fruit yield and this might be due to involvement of zinc in photosynthesis, activation of enzyme systems, protein synthesis and translocation carbohydrate. In addition, Ali *et al.* (2010), Kassem *et al.* (2011), Abd El-Migeed *et al.* (2013) and Kamiab *et al.* (2015) found that increases in yield have been obtained with polyamines (putrescine) in citrus and other fruit crop.

As for the fruit yield increase or decrease percentage data revealed that, similar trend was observed regarding the effect of treatments on fruit yield increase or decrease percentage, since the trees were treated with 10^{-3}mM/Lit (PUT) + Multi-micronutrient showed to be the superior treatment on fruit yield increase (65.27 and 148.30) than other tested treatments in both seasons, respectively.

In terms of yield, Shoeib and El-Sayed (2003) pointed out that micronutrients such as iron, zinc and boron are essential for different biological functions that might be attributed to tree yield and fruit quality. Besides, boron increases pollen grains germination, pollen tube elongation, consequently, fruit set % and total yield, cell division, biosynthesis and translocation of sugars water and nutrient uptake (Garcia-Papi and Martinez, 2003, Abd-Allah, 2006 and Ahmad *et al.,* 2009). Zn is another important microelement essential for plants due to its involvement in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis.

Also, Zn is required for the activity of various enzymes, such as dehydrogenases, aldolases, isomerases, transphosphorylases, RNA and DNA polymerases (Swietlik,1999). It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Badu and Singh, 2001, Mengel *et al.,* 2001, Dickinson *et al.,* 2003, Alloway, 2008 and Hassan *et al.* 2010).

Polyamines play different roles in the plant such as control of the flowering, fruit set, growth and development of fruit, ovary evaluation, pollen germination and growth of pollen tube (Tonon *et al.*, 2004).

Table 3. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on fruit yield (Kg/tree) and percentage of fruit yield increase or decrease of Valencia oranges during 2015 and 2016 growing seasons.

Treatments	Yield (Kg/tree)		Yield increase or decrease (%)	
	2015	2016	2015	2016
Control	19.83^{D}	14.06^{F}	1.00^{D}	1.00^{F}
Multi-micronutrient	23.15^{CD}	24.33^{BCD}	16.75^{CD}	72.02^{BCD}
10-3 m M/Lit (PUT)	26.26^{BC}	27.59^{BC}	32.78^{BC}	98.30^{BC}
10-5 mM/Lit (PUT)	22.22^{CD}	22.38^{CD}	12.06^{CD}	62.66^{CD}
10-7 mM/Lit (PUT)	28.33^{AB}	26.52^{BCD}	42.56^{B}	92.16^{BCD}
10-3 mM/Lit (PUT) + Multi-micronutrient	32.77^{A}	35.36^{A}	65.27^{A}	148.30^{A}
10-5 mM/Lit (PUT) + Multi-micronutrient	23.03^{CD}	20.59^{DE}	16.18^{CD}	48.95^{DE}
10-7 mM/Lit (PUT) + Multi-micronutrient	22.00^{CD}	15.59^{EF}	10.82^{CD}	10.01^{EF}
10-6 mM/Lit (PUT) + Multi-micronutrient	23.34^{CD}	25.19^{BCD}	17.88^{CD}	82.61^{BCD}
10-10mM/Lit (PUT) + Multi-micronutrient	22.51^{CD}	29.41^{B}	13.66^{CD}	111.60^{AB}
10-14 mM/Lit (PUT)+ Multi-micronutrient	22.66^{CD}	22.80^{CD}	14.23^{CD}	64.99^{CD}

Mean separation within treatments of the Valencia oranges according to L.S.D. at 0.05 level.

2. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on fruit quality.

a. Fruit physical characteristics:

1. Fruit weight (g), peel thickness (mm) and juice volume (cm):

Concerning the fruit weight (g) data preformed that, there were significant differences between different treatments with respect to the fruit weight (g) in both seasons. 10^{-3}mM/Lit (PUT) + Multi-micronutrient treatment gave the maximum values (245.80) of fruit weight (g) of Valencia orange when compared with other treatments including control in the first season. Meanwhile, in the second season 10^{-10} mM/Lit (PUT) + Multi-micronutrient treatment gave the maximum values (234.90), presented in Table (4).

These results were in agreement with those obtained by Qin and Qin (1996) and Rodríguez *et al.* (2005) they stated that spraying with boron achieved the highest fruit weight of mandarin, orange. Also, Yadav *et al.* (2013) proved that foliar spraying with multi-micronutrient (B, Zn and Fe) was the promising treatment for improvement of fruit weight of peach. As well as, Delgado *et al.* (1999) Fruit weight was greatly enhanced in response to application of boron. This is attributed to the great mobilization of B in olive trees during flowering and fruit development. In addition, Baghdady *et al.* (2014) indicated that foliar spraying of Valencia orange trees with Chelated calcium, Chelated zinc and boron significantly increased fruit weight. Besides, Ali *et al.* (2010), Ayad *et al.* (2011), Abd El-Migeed *et al.* (2013) and Raeisi *et al.* (2013) found that spraying putrescine at full bloom increased fruit weight of other fruit crops.

Table 4. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on fruit weight (g),peel thickness (mm)and juice volume (cm)of Valencia oranges during 2015 and 2016 growing seasons.

Treatments	Fruit weight (g)		Fruit peel thickness(mm)		Fruit juice volume (cm)	
	2015	2016	2015	2016	2015	2016
Control	194.50^{F}	161.50^{EF}	3.63^{BC}	2.87^{C}	85.23^{E}	70.30^{E}
Multi-micronutrient	202.70^{EF}	165.60^{EF}	3.73^{ABC}	3.07^{BC}	102.00^{C}	86.00^{AB}
10^{-3} m M/Lit (PUT)	243.20^{AB}	191.70^{BC}	4.10^{ABC}	3.57^{AB}	129.80^{A}	81.60^{BC}
10^{-5}mM/Lit (PUT)	219.10^{D}	165.00^{EF}	4.13^{ABC}	3.50^{AB}	105.80^{C}	73.30^{DE}
10^{-7}mM/Lit (PUT)	232.30^{BC}	180.50^{CD}	4.53^{AB}	3.27^{BC}	105.00^{C}	80.40^{BCD}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	245.80^{A}	179.30^{CD}	4.63^{A}	3.97^{A}	82.10^{E}	74.63^{CDE}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	199.40^{EF}	152.60^{F}	4.17^{ABC}	3.53^{AB}	95.53^{CD}	54.10^{F}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	196.50^{EF}	158.20^{EF}	4.15^{ABC}	3.10^{BC}	69.80^{F}	69.63^{E}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	209.10^{DE}	170.00^{DE}	3.80^{ABC}	2.80^{C}	84.95^{E}	80.30^{BCD}
10^{-10}mM/Lit (PUT) + Multi-micronutrient	220.80^{CD}	234.90^{A}	3.53^{C}	3.23^{BC}	90.90^{DE}	67.00^{E}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	198.90^{EF}	200.10^{B}	4.17^{ABC}	3.70^{AB}	120.00^{B}	89.43^{A}

Mean separation within treatments of the Valencia oranges according to L.S.D. at 0.05 level.

In regard to the fruit peel thickness (mm) data preformed that, there were significant differences between different treatments in this respect. The highest significant fruit peel thickness (mm) were recorded for 10^{-3}mM/Lit (PUT) + Multi-micronutrient treatment (4.63and 3.97), respectively in both seasons Table (4).

Concerning the fruit juice volume (cm) data preformed that, there were significant differences between the different treatments in this respect in both seasons. It was observed that fruit juice volume (cm) in the Valencia oranges was ranged from 129.80 to 89.43. fruit juice volume (cm)was increased in treatment 10^{-3} m M/Lit (PUT) (129.80) and (89.43) in both seasons, respectively, whereas decreased in 10^{-7}mM/Lit (PUT) + Multi-micronutrient treatment (69.80) and 10^{-5}mM/Lit (PUT) + Multi-micronutrient treatment (54.10) in both seasons, respectively Table (4).

b. Fruit chemical content:

1. Total soluble solids (TSS),TSS/acid ratio and Ascorbic acid (mg/100g juice):

As for the total soluble solids (TSS) percentage data preformed that, there were significant differences between the different treatments in this respect in both seasons. TSS percentage ranged from 13.53 to 11.53. 10^{-10} m M/L (PUT) + Multi-micronutrient treatment recorded the highest significant values of TSS (12.47%) in the fruit juice of Valencia orange followed by the control treatment (12.40 %) with no significant differences between them in the first season, meanwhile in the second season Multi-micronutrient treatment recorded the highest significant values of TSS (13.53 %) shown in as shown in Table (5).

These results are in consistent with those reported by Zeerban *et al.* (1994), Qin and Qin (1996), and Sarrwy *et al.* (2012) they stated that spraying with boron achieved the highest total soluble solids concentration of orange and other fruit crops. Also, Malik and Singh (2006), Marzouk and Kassem (2010), Ayad *et al.* (2011), Kassem *et al.* (2011), Abd El-Migeed *et al.* (2013), Nikfar and Abdoosi (2013) and Raeisi *et al.* (2013) stated that polyamines (Putrescine) improved total soluble solids concentration of other fruit crops.

As related to the TSS/acid ratio data revealed that, there were significant differences between different treatments with respect to the TSS/acid ratio. TSS/acid ratio ranged from 17.07 to 12.67. Control treatment recorded the highest significant values of TSS /acid ratio(0.65 %) in the fruit juice of Valencia orange in the first season, while in the second season 10^{-7}mM/Lit (PUT) treatment recorded the highest significant values (17.07) Table (5).

These data are in harmony with those reported by Ali *et al.* (2010) and Raeisi *et al.* (2013) they found that spraying putrescine at full bloom increased TSS/acid ratio of other fruit crops.

Table 5. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on percentages of total soluble solids (TSS %) and total acidity of Valencia oranges during 2015 and 2016 growing seasons.

Treatments	TSS (%)		TSS/acid ratio		Ascorbicacid (mg/100g juice)	
	2015	2016	2015	2016	2015	2016
Control	12.40^{A}	11.07^{D}	17.03^{A}	13.80^{CDE}	54.50^{ABC}	55.37^{BC}
Multi-micronutrient	11.80^{AB}	13.53^{A}	14.93^{BCD}	12.67^{E}	50.50^{BCD}	56.50^{BC}
10^{-3} m M/Lit (PUT)	10.33^{D}	11.73^{BCD}	15.77^{BC}	15.53^{B}	49.13^{CD}	60.27^{B}
10^{-5}mM/Lit (PUT)	11.67^{B}	12.00^{BCD}	15.07^{BCD}	15.00^{BC}	49.60^{CD}	53.83^{C}
10^{-7}mM/Lit (PUT)	10.27^{D}	12.50^{BC}	14.97^{BCD}	17.07^{A}	46.67^{D}	56.50^{BC}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	10.53^{D}	11.53^{CD}	14.73^{CD}	13.80^{CDE}	46.97^{D}	56.27^{BC}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	10.80^{CD}	12.60^{B}	13.13^{E}	15.47^{B}	46.93^{D}	61.07^{B}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	11.53^{B}	11.60^{BCD}	16.20^{AB}	15.30^{B}	52.50^{ABCD}	58.47^{BC}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	11.40^{BC}	12.60^{B}	15.47^{BCD}	13.50^{DE}	57.13^{AB}	66.50^{A}
10^{-10}mM/Lit (PUT) + Multi-micronutrient	12.47^{A}	12.40^{BC}	15.13^{BCD}	14.43^{BCD}	49.07^{CD}	55.40^{BC}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	11.53^{B}	12.40^{BC}	14.37^{D}	14.93^{BC}	58.40^{A}	53.80^{C}

Mean separation within treatments of the Valencia oranges according to L.S.D. at 0.05 level.

Concerning the Ascorbic acid (mg/100g juice) data preformed that, there were significant differences between different treatments including control with respect to the vitamin C (mg/100 ml juice). Ascorbic acid (mg/100g juice) was noted to the tune of 66.50 to 46.67. 10^{-14}mM/Lit (PUT) + Multi-micronutrient treatment recorded the highest significant values of Ascorbic acid (mg/100g juice) (58.40) in the fruit juice of Valencia orange in the first season, while in the second season 10^{-6}mM/Lit (PUT) + Multi-micronutrient treatment recorded the highest significant values (66.50) Table (5).

These results were coincide with those obtained by Ahmed *et al.* (1993a & b) who stated that spraying with boron achieved the highest vitamin C content of Balady mandarin fruits. In addition, Malik and Singh (2006), Ali *et al.* (2010), Marzouk and Kassem (2010) and Kassem *et al.* (2011) stated that" polyamines (Putresceine) improved on ascorbic acid content of other fruit crops.

With respect to fruit quality upon harvest, Dawood *et al.* (2000), EL-Baz (2003), Hafez and El Metwally (2007), Tariq *et al.* (2007), Abd El-Motty *et al.* (2010), Hanafy Ahmed *et al.* (2012), Sarrwy *et al.*(2012) Abd El-Motty and Orabi (2014), Salama (2015) and Gurung *et al.* (2016) found that spraying micronutrients (boron and zinc) have important role in fruit quality improvement in citrus and other fruit crops. Also, Khan *et al*. (2012) and Baghdady *et al.* (2014) indicated that foliar spraying with Chelated zinc and boron significantly increased fruit quality in orange and madarin fruits. Besides, Abd El-Migeed *et al.* (2013) found that polyamine (Putrescine) improved fruit quality in Amhat date palm.

3. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on fruit quality during storage periods (days) at room temperature:

a. Fruit weight loss percentage.

Concerning the fruit weight loss percentage data preformed that, there were significant differences between all treatments in this respect. The comparison means indicated that 10^{-3} m M/Lit (PUT) treatment as the highest of fruit weight loss (27.69 %) in the first season and 10^{-10} m M/Lit (PUT) + Multi-micronutrient treatment by (22.01%) in the second season. Whereas, 10^{-5}mM/Lit (PUT) + Multi-micronutrient treatment has least of fruit weight loss with (7.70 %) in the first season and 10^{-7}mM/Lit (PUT) + Multi-micronutrient treatment by (4.61%) or 10^{-6}m M/Lit (PUT) + Multi-micronutrient by (5.79%) in the second seasons presented in Table (6).

However, fruit weight loss percentage was significantly affected by the various storage period (days) in both seasons. The comparison means indicated that storage period (21 days) has highest of fruit weight loss (%) (36.18 and 21.72%) followed by 14 days (26.00 and 16.45 %) then 7 days (14.02 and 10.38 %) in both seasons, respectively.

Statistical analysis indicated significant differences for the interaction of various storage periods per days and all treatments. The highest fruit weight loss percentage achieved by storage period (21 days) x 10^{-3} m M/Lit (PUT) by (47.76 %) in the first season and treatment 10^{-5}m M/Lit (PUT) by (32.71 %) or 10^{-10} m M/Lit (PUT) + Multi-micronutrient by (34.62 %) in the second season with no significant differences between them.

These data are in harmony with those reported by Mirdehghan and Rahemi (2002), Serrano *et al.* (2003), Ramezanian *et al.* (2010), Malik and Singh (2005), Raeisi *et al.* (2013) and Archana *et al.* (2015) they stated that application of polyamines on storage life of Valencia orange and other fruit crops reduced weight loss of fruit. Also, Mirdehghan *et al.* (2007) pointed out that application of PUT reduced fruit weight loss during ripening as well as cold storage, which may be ascribed to consolidation or stabilization of both cell integrity and tissue permeability.

Table 6. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on percentages of fruit weight loss during storage period (days) at room temperature of Valencia oranges during 2015 and 2016 seasons.

Treatments	Storage period (days)				Mean	Storage period (days)				Mean
	0	7	14	21		0	7	14	21	
	First season; 2015					Second season; 2016				
Control	0.00^{n}	11.80^{kl}	17.91^{ij}	35.45^{b-e}	16.54^{EF}	0.00^{o}	15.78^{g-k}	19.68^{d-g}	23.56^{cde}	15.01^{C}
Multi-micronutrient	0.0^{n}	26.47^{gh}	29.99^{efg}	34.49^{c-f}	22.99^{BC}	0.00^{o}	4.56^{no}	11.63^{j-m}	19.40^{d-h}	9.14^{E}
$10^{-3 \text{ m M/Lit (PUT)}}$	0.00^{n}	21.02^{hi}	40.98^{b}	47.76^{a}	27.69^{A}	0.00o	9.18^{lmn}	15.29^{g-l}	20.35^{d-g}	11.46^{DE}
10^{-5}mM/Lit (PUT)	0.00^{n}	20.61^{hi}	37.04^{bcd}	39.26^{bc}	24.48^{B}	0.00^{o}	9.94^{k-n}	27.06^{bc}	32.71^{a}	17.68^{B}
10^{-7}mM/Lit (PUT)	0.00^{n}	10.35^{kl}	16.02^{ijk}	31.64^{d-g}	14.76^{F}	0.00^{o}	10.21^{k-n}	18.66^{d-h}	26.70^{bc}	14.15^{CD}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	2.19^{mn}	21.43^{hi}	41.49^{b}	16.53^{EF}	0.00^{o}	10.01^{k-n}	14.84^{g-l}	17.52^{e-j}	10.85^{E}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	3.91^{mn}	10.25^{kl}	15.63^{ijk}	7.70^{G}	0.00^{o}	13.38^{h-l}	17.05^{f-j}	23.87^{cd}	13.83^{CD}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	26.23^{gh}	29.14^{fg}	35.83^{b-e}	23.05^{BC}	0.00^{o}	3.28^{O}	4.41^{no}	9.76^{k-n}	4.61^{F}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	6.91^{lm}	29.83^{efg}	35.94^{b-e}	18.42^{DE}	0.00^{o}	3.33^{O}	6.53^{mno}	12.29^{i-m}	5.79^{F}
10^{-10}mM/Lit (PUT) + Multi micronutrient	0.00^{n}	10.36^{kl}	31.91^{d-g}	41.33^{b}	21.15^{CD}	0.00^{o}	22.53^{c-f}	29.86^{ab}	34.62^{a}	22.01^{A}
10^{-14}mM/Lit (PUT) + Multi micronutrient	0.00^{n}	14.34^{jk}	21.49^{hi}	39.07^{bc}	18.98^{DE}	0.00^{o}	11.97^{i-m}	15.93^{g-k}	18.07^{d-i}	11.74^{DE}
Mean	0.00^{D}	14.02^{C}	26.00^{B}	36.18^{A}		0.00^{D}	10.38^{C}	16.45^{B}	21.72^{A}	

Mean separation within treatments, storage periods of the Valencia oranges and for their interaction according to L.S.D. at 0.05 level.

b. Fruit decay (%).

As for the fruit decay percentage data revealed that, there were significant differences between all treatments in this respect. The comparison means indicated that control treatment has highest of fruit decay (%) by (32.53 and 30.34%) in both seasons, respectively. Whereas, 10^{-3}mM/Lit (PUT) + Multi-micronutrient treatment has least of fruit decay (%) with (1.00 and 1.00 %) in both seasons, respectively presented in Table (7).

Moreover, fruit decay percentage was significantly affected by the various storage periods (days) in both seasons. The comparison means indicated that storage period (21 days) has highest of fruit decay (%) by (14.50 and 15.31 %) followed by 14 days by (10.07 and 12.23 %) then 7 days by (3.00 and 4.05 %) in both seasons, respectively.

Statistical analysis indicated significant differences for the interaction of various storage periods (days) and all treatments. The highest fruit decay percentage achieved by storage period (21 days) x control treatment by (70.87 and 69.44 %) in both seasons, respectively. Meanwhile 10^{-3}mM/Lit (PUT) + Multi-micronutrient has least of fruit decay (%) by (1.00 and 1.00%) in both seasons, respectively.

These findings are in line with those reported by Porat *et al.* (2000), Plaza *et al.* (2003) and Kinary *et al.* (2005) who revealed that losses in stored orange fruit were mostly brought about by fungus attacks. Therefore, micronutrients increased resistance to disease (Tariq *et al.* 2007). Also, Polyamines increase the more longevity of fruits in storage and decrease damage of storage (Esana-ashari and Zokaeekhosroshahi, 2008).

c. Total soluble solids (TSS %).

In regard to the total soluble solids (TSS) percentage data preformed that, there were significant differences between all treatments in terms of total soluble solids percentage. The comparison means indicated that highest rate of total soluble solids percentage was related to the Multi-micronutrient treatment by (12.57 and 13.61%) in both seasons, respectively. While lowest rate was related to 10-7mM/Lit (PUT) treatment by (10.75%) in the first season and control treatment by (12.43 %) in the second seasons Table (8).

Furthermore, total soluble solids percentage was significantly affected by the various storage periods (days) in both seasons. The comparison means indicated that highest rate of total soluble solids percentage was related to the storage period (21 days) by (12.42 and 13.47%) followed by 14 days by (12.36 and 13.31%) then 7 days by (12.13 and 12.65%) in both seasons, respectively.

Statistical analysis indicated significant differences for the interaction of various storage periods (days) and all treatments in the first season, whereas there were no significant differences in the second season. Highest rate of total soluble solids percentage was related to storage period (14 days) x Multi-micronutrient by (13.00 %) followed by (21 days) x 10^{-5}mM/Lit (PUT) by (13.00 %) then (21 days) x 10^{-10}mM/Lit (PUT) + Multi-micronutrient by (13.07%) in the first season with no significant differences between them.

These results were coincide with those obtained by Raeisi *et al.* (2013) who indicated that the effect of spermidine on percentage of TSS was significant during storage period of Valencia orange fruits. Meanwhile, Khosroshahi and Ashari (2008) found out that there was low soluble solid content in putrescine treated apricot and peach fruits during storage than untreated fruits. In addition, Mirdehghan and Rahemi (2002) and Archana *et al.* (2015) reported that exogenous application of putrescine delayed changes in accumulation of soluble solid content in fruits of other fruit crops.

Table 7. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on percentages of fruit decay during storage period (days) at room temperature of Valencia oranges during 2015 and 2016 seasons.

Treatments	Storage period (days)				Mean	Storage period (days)				Mean
	0	7	14	21		0	7	14	21	
	First season; 2015					Second season; 2016				
Control	0.00^{d}	10.67^{cd}	47.57^{b}	70.87^{a}	32.53^{A}	0.00^{d}	7.33^{d}	43.57^{b}	69.44^{a}	30.34^{A}
Multi-micronutrient	0.00^{d}	1.00^{d}	23.07^{c}	17.52^{cd}	10.65^{BC}	0.00^{d}	1.00^{d}	20.91^{cd}	17.00^{d}	9.89^{B}
$10^{-3\ m\ M/Lit\ (PUT)}$	0.00^{d}	3.43^{d}	19.11^{cd}	23.12c	11.66^{B}	0.00^{d}	14.0^{d}	36.67^{bc}	37.00^{bc}	22.17^{A}
10^{-5}mM/Lit (PUT)	0.00^{d}	3.70^{d}	9.44^{cd}	12.85^{cd}	6.74^{BCD}	0.00^{d}	3.23^{d}	8.24^{d}	12.25^{d}	6.18^{B}
10^{-7}mM/Lit (PUT)	0.00^{d}	1.00^{d}	1.00^{d}	2.52^{d}	1.37^{D}	0.00^{d}	1.00^{d}	1.00^{d}	1.78^{d}	1.19^{B}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	0.00^{d}	1.00^{d}	1.00^{d}	1.00^{d}	1.00^{D}	0.00^{d}	1.00^{d}	1.00^{d}	1.00^{d}	1.0^{B}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	0.00^{d}	1.00^{d}	4.17^{d}	18.85^{cd}	6.25^{BCD}	0.00^{d}	1.00^{d}	3.13^{d}	17.33^{d}	5.61^{B}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	0.00^{d}	3.84^{d}	2.42^{d}	1.00^{d}	2.96^{CD}	0.00^{d}	11.78^{d}	17.3^{d}	4.37^{d}	8.62^{B}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	0.00^{d}	1.00^{d}	1.00^{d}	4.59^{d}	1.89^{D}	0.00^{d}	1.00^{d}	1.00^{d}	3.84^{d}	1.71^{B}
10^{-10}mM/Lit (PUT) + Multi-micronutrient	0.00^{d}	5.43^{cd}	1.00^{d}	1.00^{d}	2.10^{D}	0.00^{d}	2.25^{d}	1.00^{d}	1.00^{d}	1.31^{B}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	0.00^{d}	1.000^{d}	1.00^{d}	2.63^{d}	1.40^{D}	0.00^{d}	1.00^{d}	1.00^{d}	3.44^{d}	1.61^{B}
Mean	0.00^{B}	3.00^{B}	10.07^{A}	14.50^{A}		0.00^{B}	4.05^{B}	12.23^{A}	15.31^{A}	

Mean separation within treatments, storage periods of the Valencia oranges and for their interaction according to L.S.D. at 0.05 level.

Table 8. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on percentages of total soluble solids (TSS %) during storage period (days) at room temperature of Valencia oranges during 2015 and 2016 seasons.

Treatments	Storage period (days)				Mean	Storage period (days)				Mean
	0	7	14	21		0	7	14	21	
	First season; 2015					Second season; 2016				
Control	12.40^{a-g}	12.30^{b-h}	12.13^{c-i}	12.80^{abc}	12.41^{AB}	11.07^{a}	12.67^{a}	12.93^{a}	13.07^{a}	12.43^{D}
Multi-micronutrient	11.80^{g-l}	12.80^{abc}	13.00^{a}	12.67^{a-d}	12.57^{A}	13.53^{a}	12.70^{a}	14.20^{a}	14.00^{a}	13.61^{A}
$10^{-3\ m\ M/Lit\ (PUT)}$	10.33^{p}	11.83^{f-l}	12.47^{a-f}	11.67^{h-l}	11.57^{C}	11.73^{a}	12.40^{a}	12.47^{a}	14.27^{a}	12.72^{BCD}
10^{-5}mM/Lit (PUT)	11.67^{h-l}	11.97^{e-k}	12.83^{ab}	13.00^{a}	12.37^{AB}	12.00^{a}	12.00^{a}	13.07^{a}	13.00^{a}	12.52^{CD}
10^{-7}mM/Lit (PUT)	10.27^{p}	10.47^{op}	11.27^{lmn}	11.00^{mno}	10.75^{D}	12.50^{a}	12.10^{a}	13.07^{a}	13.60^{a}	12.82^{BCD}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	10.53^{op}	11.53^{i-m}	12.67^{a-d}	12.07^{d-j}	11.70^{C}	11.53^{a}	12.00^{a}	13.07^{a}	14.07^{a}	12.67^{BCD}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	10.80^{nop}	12.60^{a-e}	12.80^{abc}	12.47^{a-f}	12.17^{B}	12.60^{a}	13.07^{a}	13.20^{a}	12.00^{a}	12.72^{BCD}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	11.53^{i-m}	12.63^{a-e}	12.17^{b-i}	12.73^{a-d}	12.27^{AB}	11.60^{a}	12.80^{a}	13.60^{a}	13.47^{a}	12.87^{BC}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	11.40^{klm}	12.20^{b-h}	12.60^{a-e}	12.73^{a-d}	12.23^{B}	12.60^{a}	13.00^{a}	13.20^{a}	13.27^{a}	13.02^{B}
10^{-10}mM/Lit (PUT) + Multi-micronutrient	12.47^{a-f}	12.63^{a-e}	11.47^{j-m}	13.07^{a}	12.41^{AB}	12.40^{a}	13.40^{a}	14.40^{a}	13.80^{a}	13.50^{A}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	11.53^{i-m}	12.47^{a-f}	12.60^{a-e}	12.40^{a-g}	12.25^{B}	12.40^{a}	13.00^{a}	13.20^{a}	13.60^{a}	13.05^{B}
Mean	11.34^{C}	12.13^{B}	12.36^{A}	12.42^{A}		12.18^{C}	12.65^{B}	13.31^{A}	13.47^{A}	

Mean separation within treatments, storage periods of the Valencia oranges and for their interaction according to L.S.D. at 0.05 level.

d. TSS/acid ratio.

Concerning the TSS/acid ratio data preformed that, there were significant differences between all treatments with respect to the TSS/acid ratio. The comparison means indicated that lowest rate of TSS/acid ratio was related in 10^{-10}mM/Lit (PUT) + Multi-micronutrient with (14.19) treatment and highest rate was related in 10^{-6}mM/Lit (PUT) + Multi-micronutrient with (17.10) treatment in the first season. Whereas, Multi-micronutrient treatment has least of TSS/acid ratio with (12.43) and highest rate was related in 10^{-3} m M/Lit (PUT) with (17.72) treatment in the second season Table (9).

Moreover, TSS/acid ratio was significantly affected by the various storage periods (days) in the second season, while they were insignificant in the first season. The comparison means indicated that lowest rate of TSS/acid ratio was related in storage period (21 days) with (14.26) and highest rate was related in storage period (14 days) with (15.62) in the second season.

Statistical analysis indicated significant differences for the interaction of various storage periods (days) and all treatments. Lowest rate of TSS/acid ratio was related in storage period (7 days) x 10^{-6} mM/Lit (PUT) + Multi-micronutrient with (14.53) and highest rate was related in storage period (7 days) x 10^{-10} mM/Lit (PUT) + Multi-micronutrient with (19.00) in the first season. Whereas, in the second season lowest rate of TSS/acid ratio was related in storage period (21days) x Multi-micronutrient with (9.40) and highest rate was related in storage period (7 days) x Control with (22.20) in the second season.

These results are in accordance with those reported by Raeisi *et al.* (2013) who indicated that the effect of spermidine on percentage of TSS/acid was significant during storage period of Valencia orange fruits.

Table 9. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on TSS/acid ratio during storage period (days) at room temperature of Valencia oranges during 2015 and 2016 seasons.

Treatments	Storage period (days)				Mean	Storage period (days)				Mean
	0	7	14	21		0	7	14	21	
	First season; 2015					Second season; 2016				
Control	17.03^{bc}	15.03^{l-M}	15.60^{e-k}	14.97^{i-m}	15.66^{C}	13.80^{l-o}	22.20^{a}	16.30^{d-i}	14.33^{j-o}	16.66^{B}
Multi-micronutrient	14.93^{i-m}	15.00^{i-m}	15.63^{e-k}	14.70^{j-m}	15.07^{D}	12.67^{o}	14.40^{j-o}	13.27^{m-o}	9.40^{p}	12.43^{D}
10^{-3} m M/Lit (PUT)	15.77^{d-j}	14.57^{klm}	14.30^{m}	15.43^{f-m}	15.02^{D}	15.53^{f-l}	21.33^{ab}	16.80^{c-h}	17.20^{c-f}	17.72^{A}
10^{-5}mM/Lit (PUT)	15.07^{i-m}	15.20^{h-m}	16.77^{bcd}	15.60^{e-k}	15.66^{C}	15.00^{i-m}	14.10^{j-o}	15.40^{g-l}	14.03^{k-o}	14.63^{C}
10^{-7}mM/Lit (PUT)	14.97^{i-m}	15.80^{d-j}	16.03^{c-i}	15.23^{h-m}	15.51^{CD}	17.07c-g	17.50^{cde}	17.63^{cd}	14.07^{j-o}	16.57^{B}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	14.73^{j-m}	15.37^{g-m}	15.17^{h-m}	15.83^{d-j}	15.27^{CD}	13.80l-o	17.43^{cde}	18.17^{c}	15.60^{f-k}	16.25^{B}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	13.13^{n}	15.00^{i-m}	15.00^{i-m}	17.10^{bc}	15.06^{D}	15.47^{f-l}	15.37^{g-l}	15.80^{e-k}	13.77^{l-o}	15.10^{C}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	16.20^{c-h}	16.60^{b-e}	16.43^{b-g}	16.40^{b-g}	16.41^{B}	15.30^{h-l}	16.33^{d-i}	17.97^{cd}	14.73^{i-n}	16.08^{B}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	15.47^{f-l}	19.00^{a}	17.43^{b}	16.50^{b-f}	17.10^{A}	13.50^{mno}	16.40^{d-i}	20.13^{b}	13.50^{mno}	15.88^{B}
10^{-10}mM/Lit (PUT) + Multi-micronutrient	15.13^{h-m}	14.53^{klm}	12.10^{o}	15.00^{i-m}	14.19^{E}	14.43^{j-o}	17.23^{c-f}	14.90^{i-n}	13.13no	14.93^{C}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	14.37^{lm}	15.77^{d-j}	17.30^{b}	15.07^{i-m}	15.63^{C}	14.93^{i-m}	17.13^{c-g}	15.83^{e-j}	17.13^{c-g}	16.26^{B}
Mean	15.16^{B}	15.62^{A}	15.62^{A}	15.62^{A}		14.68^{C}	17.22^{A}	16.56^{B}	14.26^{C}	

Mean separation within treatments, storage periods of the Valencia oranges and for their interaction according to L.S.D. at 0.05 level.

e. Ascorbic acid (mg/100g juice).

As for the ascorbic acid (mg/100g juice)data revealed that, there were significant differences between all treatments in this respect. The comparison means indicated that Multi-micronutrient treatment has highest of ascorbic acid (mg/100g juice)with (69.13) and 10^{-7}mM/Lit (PUT) treatment has least with (56.84) in the first season. Meanwhile, in the second season 10^{-3} m M/Lit (PUT) treatment has highest of ascorbic acid (mg/100g juice)with (62.92) and 10^{-5}mM/Lit (PUT) treatment has least with (54.55) presented in Table (10).

Table 10. Effect of multi-micronutrient and putrescine application alone or in combination at different concentrations on ascorbic acid (V.C mg/100g juice)duringstorage period (days) at room temperature of Valencia oranges (season 2015).

Treatments	Storage period (days)				Mean	Storage period (days)				Mean
	0	7	14	21		0	7	14	21	
	First season; 2015					Second season; 2016				
Control	0.00^{n}	11.80^{kl}	17.91^{ij}	35.45^{b-e}	16.54^{EF}	0.00^{o}	15.78^{g-k}	19.68^{d-g}	23.56^{cde}	15.01^{C}
Multi-micronutrient	0.0^{n}	26.47^{gh}	29.99^{efg}	34.49^{c-f}	22.99^{BC}	0.00^{o}	4.56^{no}	11.63^{j-m}	19.40^{d-h}	9.14^{E}
$10^{-3 \text{ m M/Lit (PUT)}}$	0.00^{n}	21.02^{hi}	40.98^{b}	47.76^{a}	27.69^{A}	0.00o	9.18^{lmn}	15.29^{g-l}	20.35^{d-g}	11.46^{DE}
10^{-5}mM/Lit (PUT)	0.00^{n}	20.61^{hi}	37.04^{bcd}	39.26^{bc}	24.48^{B}	0.00^{o}	9.94^{k-n}	27.06^{bc}	32.71^{a}	17.68^{B}
10^{-7}mM/Lit (PUT)	0.00^{n}	10.35^{kl}	16.02^{ijk}	31.64^{d-g}	14.76^{F}	0.00^{o}	10.21^{k-n}	18.66^{d-h}	26.70^{bc}	14.15^{CD}
10^{-3}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	2.19^{mn}	21.43^{hi}	41.49^{b}	16.53^{EF}	0.00^{o}	10.01^{k-n}	14.84^{g-l}	17.52^{e-j}	10.85^{E}
10^{-5}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	3.91^{mn}	10.25^{kl}	15.63^{ijk}	7.70^{G}	0.00^{o}	13.38^{h-l}	17.05^{f-j}	23.87^{cd}	13.83^{CD}
10^{-7}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	26.23^{gh}	29.14^{fg}	35.83^{b-e}	23.05^{BC}	0.00^{o}	3.28^{O}	4.41^{no}	9.76^{k-n}	4.61^{F}
10^{-6}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	6.91^{lm}	29.83^{efg}	35.94^{b-e}	18.42^{DE}	0.00^{o}	3.33^{O}	6.53^{mno}	12.29^{i-m}	5.79^{F}
10^{-10}mM/Lit (PUT) + Multi- micronutrient	0.00^{n}	10.36^{kl}	31.91^{d-g}	41.33^{b}	21.15^{CD}	0.00^{o}	22.53^{c-f}	29.86^{ab}	34.62^{a}	22.01^{A}
10^{-14}mM/Lit (PUT) + Multi-micronutrient	0.00^{n}	14.34^{jk}	21.49^{hi}	39.07^{bc}	18.98^{DE}	0.00^{o}	11.97^{i-m}	15.93^{g-k}	18.07^{d-i}	11.74^{DE}
Mean	0.00^{D}	14.02^{C}	26.00^{B}	36.18^{A}		0.00^{D}	10.38^{C}	16.45^{B}	21.72^{A}	

Mean separation within treatments, storage periods of the Valencia oranges and for their interaction according to L.S.D. at 0.05 level.

Moreover, ascorbic acid (mg/100g juice) was significantly affected by the various storage periods (days) in both seasons. The comparison means indicated that storage period (21 days) has highest of ascorbic acid (mg/100g juice) with (71.26 and 64.57) in both season, respectively. While, storage periods (0 Time) and (14 days) has least with (51.04 and 53.74) in the first and second season, respectively.

Statistical analysis indicated significant differences for the interaction of various storage periods (days) and all treatments. Storage period (21days) x Multi-micronutrient has highest of ascorbic acid (V.C mg/100g juice)with (81.53) and storage period (0 Time) x 10^{-7}mM/Lit (PUT) has least with (46.67) in the first season. Meanwhile, in the second season storage period (21days) x 10^{-3} m M/Lit (PUT) has highest of ascorbic acid (V.C mg/100g juice)with (74.43) and storage period (7days) x 10^{-5}mM/Lit (PUT) has least with (47.40).

These results were in agreement with those obtained by Raeisi *et al.* (2013) who revealed that the effect of spermidine on percentage of vitamin C was significant during storage period of Valencia orange fruits.

In terms of fruit quality during storage, Kramer *et al.* (1991) and Valero *et al.* (2002) speculated that, polyamines might maintain fruit quality by stabilizing cell walls, or by making cell walls less accesstible to wall-softening enzymes. Reduction of apple fruit softening has been correlated with increasing the levels of endogenous polyamines (Kramer *et al.*, 1989).

Putrescine application leads to changes in cell wall stability (Messiaen *et al.,* 1997) by inhibition of the action of polygalacturonase and pectin methyl esterase involved in softening, and also cross-link pectin substances in the cell wall, producing rigidification and increasing fruit firmness (Martinez-Romero *et al.,* 2002 and Perez-Vicente *et al*., 2002).Most of the research indicates that polyamines have a role in delaying ripening and senescence and ultimately its shelf-life in many fruits like plum (Serrano *et al.,* 2003), mango (Aman and Zora*,* 2006 and Jawandha *et al.,* 2012), kiwifruit (Jhalegar *et al.,* 2012) and banana (Archana *et al.,* 2015).

Torrigiani*et al.*, (2004) indicated that Pre-storage PUT application has been reported to significantly suppress ethylene production and delay ripening in mango fruit. Also, Malik and Singh (2005) found that PAs act as anti-senescence agents which delayed the softening in mango.

As well as, Khan *et al.* (2007) stated that PAs act as anti-senescence agents which delayed the softening in plum. In addition, Khan *et al.* (2008) mentioned that postharvest PUT application had been found to increase the total antioxidant activity in 'Angelino' plum. Also, Davarynejad *et al.* (2013) found that postharvest PUT application had been found to increase the total antioxidant activity in 'Lasgerdi' and 'Shahrodi' apricot.During post-harvest polyamines have anti-senescence function by inhibition of the formation of enzymes essential to the synthesis of ethylene thus, reduced physiological weight loss, delaying ripening and extend fruit shelf life (Valero *et al.*, 2002, Malik *et al.*, 2003, Malik and Singh, 2005, Aman and Zora*,* 2006, Jawandha *et al.*, 2012 and Mohammad *et al.*, 2013).

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تأثير الرش الورقي بعديدات الأمين وبعض العناصر الصغرى على الإنتاجية والقدرة التخزينية للبرتقال الفالنشيا

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أجريت هذه الدراسة خلال موسمي ٢٠١٥، ٢٠١٦ م على ثلاثة وثلاثين شجرة من البرتقال الصيفي عمرها عشر سنوات، مطعومة على أصل الفولكاماريانا، نامية في ارض رملية، خاضعة لنظام الري بالتنقيط وذلك في مزرعة الموالح الخاصة بكلية الزراعة بالكوامل جامعة سوهاج، الأشجار المختارة (٣٣ شجرة) من البرتقال الصيفي تم تصميمها في قطاعات كاملة العشوائية مع ثلاث مكررات للتحليل، خلال التخزين استخدم ٥ ثمار لكل مكررة لتقييم صفات الجودة الخاصة بها. كان الهدف من هذه الدراسة هو دراسة تأثير الرش الورقي بالعناصر الصغرى (الحديد ٢٥٠ جزء/مليون، الزنك ٢٠٠ جزء/مليون، البورون ١%) والأحماض الأمينية متمثلة في البتروسين ($١٠^{-٣}$، $١٠^{-٥}$، $١٠^{-٧}$ ملي مول/لتر) سواء رشها منفردة أو بواسطة عمل توليفة بينها أثناء الإزهار الكامل وبعد عشرة أيام من عقد الثمار على الإنتاجية وبعض صفات الجودة للثمار عند جمع المحصول وكذلك أثناء التخزين على درجة حرارة الغرفة (الجو المحيط) وذلك لتحسين تسويق البرتقال الصيفي دون خسارة اقتصادية.وجد أن معاملة البتروسين بتركيز $١٠^{-٣}$ ملي مول/لتر + العناصر الصغرى أعطت أعلى القيم لنسبة العقد، للمحصول النهائي/شجرة،ووزن الثمرة (جم)، وحجم الثمار (سم^{٣})، ووزن عصير الثمرة (جم)، وحجم عصير الثمرة (سم) وسمك قشرة الثمرة (مم) للبرتقال الفالنشيا. وكذلك أعطت أعلى معدل من نسبة المواد الصلبة الذائبة الكلية، نسبة المواد الصلبة الذائبة الكلية إلى الحموضة، وحمض الأسكوربيك (فيتامين سى ملجم/١٠٠جم عصير) وأدنى القيم لنسبة تلف الثمار أثناء فترة التخزين. توصى هذه الدراسة بأن معاملة البتروسين بتركيز $١٠^{-٣}$ ملي مول/لتر + العناصر الصغرى يمكن اعتبارها تكنولوجيا مفيدة لتحسين نسبة العقد، المحصول النهائي، وزن الثمرة (جم)، حجم عصير الثمرة (سم) وسمك قشر الثمرة (مم) عند جمع محصول البرتقال فالنشيا، كذلك نفس المعاملة لتجنب التأثيرات السلبية على الجودة أثناء تخزين الثمار على درجة حرارة الغرفة (الجو المحيط) خاصة زيادة معدل نسبة المواد الصلبة الذائبة الكلية، نسبة المواد الصلبة الكلية إلى الحموضة، حامض الأسكوربيك (فيتامين سى ملجم/١٠٠جم عصير) لتحسين إمكانية تسويق البرتقال الفالنشيا دون خسارة اقتصادية.