Effect of Preharvest Sitofex Spraying on Yield and Fruit Characteristics of "Kelsey" Plum during Cold Storage

Ennab, H.A.; M.A. El Shemy* and S.K. Okba
Horticulture Research Institute, Agriculture Research Center, Giza, Egypt
*Corresponding author e-mail: mervatabd22@yahoo.com, Tel. 01018701868

ABSTRACT

This investigation was conducted during 2018 and 2019 seasons at Abu El-Matamir, El-Beheira governorate, Egypt on "Kelsey" plum trees. The trees were eight years old, budded on Mariana rootstock, planted at 4 × 5 meters apart in calcareous soil under drip irrigation system. Foliar spray of sitofex (CPPU) at 0, 2.5, 5, 7.5, 10, 12.5 and 15 ppm were done twice at full bloom and after two weeks from full bloom to assess their effect on yield and fruit quality during storage at 0 ±1°C with 90 ± 95% RH for 28 days. The results showed that, foliar spraying of "Kelsey" plum trees with sitofex (CPPU) at concentration of 10, 12.5 and 15 ppm significantly enhanced fruit set and reduced fruit drop as well as produced high yield with heaviest and largest fruits reached at harvest stage. Moreover, these three concentrations were the most effective treatments maintaining the quality characters during cold storage at 0 ±1°C with 90 ± 95% RH showing the lowest fruit weight loss and decay. Also, these three concentrations gave the highest fruit firmness and maintained SSC%, acidity, SSC/acid ratio and ascorbic acid content till 28 days of cold storage. It could be storage recommended that spraying "Kelsey" plum trees with sitofex at 10 ppm twice at the full bloom and after two weeks from full bloom which is considered the best and economic treatment used for enhancing flowering, producing maximum yield and improving fruit quality particularly fruit size as well as maintaining the overall quality of "Kelsey" plum fruits during storage at 0 ±1°C with 90 ± 95% RH for 28 days.

Key words: *Prunus salicina,* sitofex, CPPU, fruit quality, firmness, ascorbic acid, TSS%.

INTRODUCTION

Japanese plum (*Prunus salicina* Lindl.) is one of the most important deciduous fruit grown in Egypt; it is fairly good source of fibers, vitamins, antioxidants and minerals such as calcium, magnesium, iron and potassium which are essential for human health (Lozano *et al.,* 2009). Japanese plums are generally consumed freshly, and their varieties fruits differ in shape, size, taste, appearance, and ability to maintaining fruit quality after harvest (Manganaris *et al.,* 2008). In this respect, small fruit size is one of the limiting factors affecting fruit marketing. So, enhancing flowering, producing maximum yield and improving fruit quality particularly fruit size as well as maintaining the overall quality of the fruits during storage and marketing are considered essential aims of plum production Therefore, using exogenous applications of CPPU aimed to ensure economical yield with a good quality and extend shelf life of plum fruits. In this sense, synthetic cytokinin sitofex (CPPU) is effective horticultural treatment for enhancing fruit growth and size when applied at low rates and increase fruit firmness as well as delay maturation (Flaishman *et al.,* 2001 and Zoffoli *et al.,* 2009). Moreover, forchlorofenuronis (CPPU) or N-(2-Chloro-4-pyridyl) - N - phenylurea is effective for reducing fruit drop and improve fruit set; yield and produce large fruit size through stimulating cell division and cell elongation (Curry and Greene 1993 and Sugiyama and Yamaki 1995). In this respect, Ahmed and Abd El Aal (2007) obtained the best results with regard to yield and fruit quality when CPPU was sprayed at 10 ppm during two weeks after fruit set; besides that, application of sitofex at 5, 10 and 15 ppm was responsible in delaying maturity stage in terms of decreasing total soluble solids % and total sugars % compared to the control. Also, Guirguis *et al.,* (2010) observed that "Costata" persimmon trees sprayed with 10 ppm sitofex (CPPU) at two weeks after full bloom produced maximum yield and improved fruit quality, especially fruit weight, size, dimensions and firmness as well as delayed fruit maturation expressed by the lowest TSS% and the highest acidity% in the juice. Similar responses were reported by Assad (2013) who found that spraying CPPU at 5 or 10 ppm after one week of full bloom on Hollywood and Santarosa Japanese plum recorded the highest values of fruit set, yield, fruit weight, size, length, diameter, firmness and acidity and the lowest values of fruit drop and TSS as compared with control.

So, it seemed that preharvest spraying with sitofex (CPPU) led to delay the fruit maturity and extend shelf life in some fruits including 'McIntosh' and 'Royal Gala' apples, (Greene 1996 & Stern *et al.,* 2003); 'Hayward' kiwifruit (Costa *et al.,* 1997), 'Duke' blueberry (Retamales *et al.,* 2014) and 'Alphonso' mango (Pujari *et al.,* 2016). In this concern, Patterson *et.al* (1993) concluded that, CPPU has a great potential to increase the fruit size of kiwifruit when applied at low concentration, also spraying CPPU at 5 mg/liter improved fruit firmness and soluble solids concentration during long term storage at 0 ± 1°C. Also, Curry and Greene (1993) reported that, spraying apple trees with CPPU at 0, 6. 25, 12.5, 25 and 50 mg/liter twice at full bloom and two weeks later in increased in fruit firmness at harvest time and maintained it during 28 weeks under cold storage condition. El Abbasy *et al.*, (2015) revealed that clusters of Thomson seedless grapevine sprayed with 6 ppm sitofex at 4 mm berries diameter showed the lowest percent of weight loss, fruit decay and increase the marketable fruit after 60 days of cold storage. In this line, Taha and Abd El Ghany (2016) revealed that spraying Anna apple trees with CPPU at rate of 10 ppm at full bloom, fruit set and at one month before harvest had significantly increased fruit set, yield, and fruit quality as well as reduced fruit weight loss and maintained fruit firmness during storage at 3°C for 12 weeks. Thus, it is obvious from previous studies that, preharvest spraying with sitofex (CPPU) delayed fruit maturity which appear in the lowest SSC% and highest acidity %, so this point will be in great importance for delaying the harvest date, extend shelf life of plum fruits.

Therefore, this investigation was conducted to examine further the effect of preharvest application with sitofex (CPPU) on tree fruiting, yield and fruit size of “Kelsey” plum trees as well as fruit quality during cold storage.

MATERIALS AND METHODS

The present study was carried out in a private orchard at Abu El-Matamir, El-Bohaira governorate, Egypt, during 2018 and 2019 seasons to study the effect of sitofex spraying on "Kelsey” plum trees productivity and fruit quality characteristics during cold storage. In this trial, eight years old "Kelsey” plum (*Prunus salicina* Lindl.) trees budded on Mariana rootstock, and planted at 4 × 5 meter apart in calcareous soil under drip irrigation system were used. The soil texture was sandy (7.73% clay, 15.19% silt and 77.08% sand), with electrical conductivity 1.38dsm^{-1} and pH of 8.15. Sixty three trees uniform in growth, vigour and productivity were selected, and subjected to the same cultural practices commonly adopted on the orchard. The chosen trees were arranged in a randomized complete block design, each treatment replicated three times with three trees for each replicate. Seven concentrations; 0 (control), 2.5, 5, 7.5, 10, 12.5 and 15 ppm were prepared from sitofex compound (0.01%) as a source of CPPU; each tree was sprayed twice at full bloom and after two weeks from the full bloom by solution 10 L/tree using a handheld sprayer until runoff in the early morning. The following data were recorded at harvest:

1. Yield components:

1.1. Fruit set and fruit drop %:

Number of flowers, fruitlets at initial set (15 days after full bloom) and fruit at harvest time were counted on selected main branches in four directions on each tree for calculated final fruit set and fruit drop percentages by using the following equations:

$$\text{Fruit set \%} = \frac{\text{No. of harvested fruits}}{\text{No. of flowers}} \times 100$$

$$\text{Fruit drop \%} = \frac{\text{No. of fruitlets at initial set} - \text{No. of harvested fruits}}{\text{No. of fruitlets at initial set}} \times 100$$

1.2. Yield:

Yield was harvested at July 26th and 29th in 2018 and 2019, respectively. Yield of each replicate was determined as kg/tree and total yield as ton/feddan.

1.3. Fruit weight and fruit size:

Fruit weight (g) was measured using digital balance and fruit size (cm^3) was determined by using water displacement method according to A.O.A.C., (1990).

2. Storage ability:

At harvest time, fruit samples were selected for uniform size, color and free from physical injuries, insect attack and damage, sunburn, blemishes and bruises. Fruit samples were directly transported to laboratory of Sakha Horticulture Research Station, Kafr El-Sheikh governorate, cleaned, washed by distilled water, left until surface dry and then divided into two groups; the first one was used for achieving the initial quality parameters at harvest time. However, the second one was packed in 40×25×15 cm carton boxes dimensions; each box contained 3kg of Kelsey plum fruits. All boxes were stored in cold room at 0 ± 1 °C with relative humidity (RH) 90 – 95 % for 28 days. Each treatment replicated three times for each sample date. The variables were measured at 7 days intervals during storage period as follow:

2.1. Weight loss %:

Kelsey plum fruits were weighed at zero time (before storage) and reweighted again at each ex-storage date during the storage period. Weight loss was calculated according to the following equation: Fruit weight loss %= (W_I – W_S) / W_I × 100 Where, W_I = fruit weight before storage. Ws = fruit weight after each storage period.

2.2. Fruit decay %:

Fruit decay% was determined by calculating the number of decayed fruits on the sampling date and expressed as a percentage of fruit decay according to the following equation: Fruit decay% = {No. of decayed fruits ÷ Initial No. of stored fruits} × 100

2.3. Fruit firmness (Newton):

Fruit firmness was examined in two sides of the fruit using pressure tester (Digital force-Gouge Model FGV-0.5A to FGV–100A.shimpo instruments).

2.4. Soluble solids content %:

Soluble solids content of the fruit was recorded with the help of hand refractometer.

2.5. Titratable acidity%:

The acidity of the fruit juice was estimated by titrating against standard alkali solution (0.1N NaOH) using phenolphthalein indicator and expressed as percentage of malic acid/100 ml of juice according to A.O.A.C. (1990),

2.6. SSC/acid ratio:

SSC/acid ratio was estimated.

2.7. Ascorbic acid mg/100 ml juice:

Ascorbic acid was determined by using 2, 6 dichlorophenol indophenol pigment according to Rangana, (1977).

3. Statistical analysis:

The experimental treatments were arranged in a randomized complete block design. The data of fruit set fruit drop, yield, fruit at harvest and fruit size were analyzed using analysis of variance in a one-way. The measured variables during storage period were analyzed as factorial experiment with two factors: CPPU concentrations (A) and storage period (B). The obtained data were statistically analyzed using SAS software Version 9.1 according to Snedecor and Cochran (1990) and the least significant differences (L.S.D. at 5% level) were used to compare the mean values.

RESULTS AND DISCUSSION

1. Yield components:

1.1. Fruit set and fruit drop (%):

The results in Figure 1 cleared that all of sitofex concentrations significantly increased fruit set % as compared to control. Foliar application of CPPU at 15 and 12.5 ppm recorded the highest significant values of fruit set followed by 10 ppm, whereas the lowest values were obtained from unsprayed trees. The results are in harmony with the findings of Hota *et al.,* (2017). In this line, Assad (2013) reported that spraying Hollywood and Santarosa plums by CPPU at 10 ppm after one week from full bloom recorded the highest values of fruit set. The increase in fruit set as a result of different concentrations of CPPU might be due to its effect on retarding formation of abscission layer, enhanceing resistance to water and nutrient stress and improving photosynthesis and mobilization of metabolites to the flowers. This result was supported by Guirguis *et al.*, (2010). With regard to the effect of sitofex on fruit drop%, results presented in figure 2 indicate that spraying CPPU significantly decreased the percentage of fruit drop compared to control treatment. This decrease was proportional to the concentrations of CPPU. In other words, the lowest value of this parameter was found in trees sprayed with CPPU at 15 and 12.5 ppm followed by that received 10 ppm, respectively. On the contrary, the highest values of fruit drop % were always concomitant to unsprayed trees. These results are in agreement with those found by Ahmed and Abd El Aal (2007) and Guirguis *et al.*, (2010). In this respect, Assad (2013) revealed that spraying sitofex at 10 ppm CPPU after one week of full bloom recorded the lowest values of fruit drop of Hollywood and Santarosa plum trees.

It is obvious from results in Figures 1 and 2 that, fruit set and fruit drop of Kelsey plum trees were significantly affected by sprayed sitofex at different concentrations as compared with unsprayed trees. The increase in fruit set % and the decrease in fruit drop % were proportional to the increase of sitofex concentration. Moreover, spraying sitofex (CPPU) at 15, 12.5 and 10 ppm appeared to be superior in improving fruit set and reducing fruit drop as compared with control and other treatments in this study. The obtained results are in line with the previously reported by Guirguis *et al.*, (2010), Assad (2013) and Khot *et al.*, (2015).

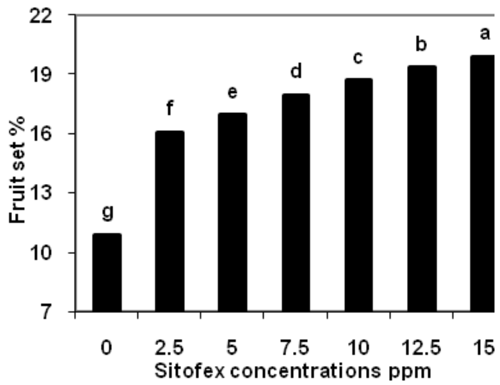

Figure 1: Effect of preharvest sitofex spraying on fruit set % of Kelsey plum trees (average of two seasons).

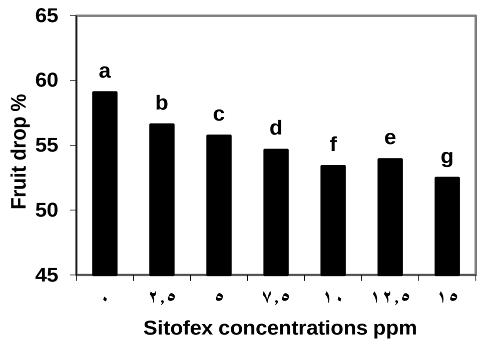

Figure 2: Effect of preharvest sitofex spraying on fruit drop % of Kelsey plum trees (average of two seasons).

1.2. Yield:

Results in Figures 3 and 4 showed that, spraying CPPU significantly improved yield of Kelsey plum expressed as kg/tree and ton/feddan. In this sense, the entire sitofex concentrations significantly increased fruit yield as compared to control (Figures 3 and 4). Spraying CPPU at 10 ppm tended to give the highest values of yield as kg/tree and ton/feddan followed by 15 and 12.5 ppm, respectively. On contrary, unsprayed trees (control) produced the lowest values of fruit yield. These results are in agreement with those obtained by Ahmed and Abd El Aal (2007) and Banyal *et al.* (2013). They reported that, application of sitofex at 10 and 15 ppm significantly increased the yield of Le Conte pear and apple trees. Also, Guirguis *et al.* (2010) and Assad (2013) revealed that persimmon and plum trees sprayed with CPPU at 10 ppm had higher yield (kg/tree) than unsprayed trees. The increase in tree yield might be due to treatments of CPPU which influenced the increase on fruit set, reduce fruit drop (Figures 1 and 2), positive effect on growth and development of fruits resulted into increase the large fruit size reached to the stage of harvest (Figure 6). Also, an increase in fruit weight (Figure 5) resulted from accumulation of dry matter in the fruits, rapid cell division and elongation and consequently increased the yield. Similarly, higher yield was obtained by Marvet *et al.* (2001) in Thompson Seedless' grapevines, following the application of sitofex (CPPU) when applied at7 ppm. Stern *et al.* (2006) stated that the improving effect of Sitofex on fruit weight and dimensions, as well as on reducing pre-harvest fruit drop resulted in increased fruit yield in apple. These findings related to higher yield with CPPU are in agreement with those obtained by Ogata *et al,* (1989).

1.3. Fruit weight and size:

Data presented in Figures 5 and 6 revealed that different sitofex concentrations considerably increased fruit weight and fruit size as compared with control. The heaviest and largest fruits were obtained by using CPPU at 10 ppm followed by 12.5 and 15 ppm, respectively. These results are in harmony with those reported by El Sabagh (2002) and Guirguis *et al.*, (2010) on Anna apple and Costata persimmon trees. They concluded that fruit weight, fruit volume and dimensions were gradually increased by increasing the concentration of CPPU up to 10, 15 or 20 ppm. The increase in fruit weight and size may be due to application of CPPU which might be described to its positive action on enhancing both cell division and cell elongation as well as its great role in activating the biosynthesis of proteins, RNA and DNA (Curry and Greene, (1993). These results are in accordance with those reported by Zhang *et al.* (2008) and Kim *et al.* (2006) who found that CPPU was effective in enhancing fruit weight in pear and kiwifruit by stimulating cell division and cell expansion. Kittiwatsopon and Karintanyakit (2014) also found that 5 ppm CPPU applied seven days before flowering or 10 ppm CPPU applied seven days after full bloom increased berry size in grape cv. Perlette. Serri and Hepp (2006) revealed that there was an increase in berry size with the application of CPPU in 'High Bush' Blueberries. In this sense, Assad (2013) concluded that spraying CPPU at 10 ppm after one week of full bloom recorded the highest values of fruit weight, fruit size and firmness of Hollywood and Santarosa plum trees.

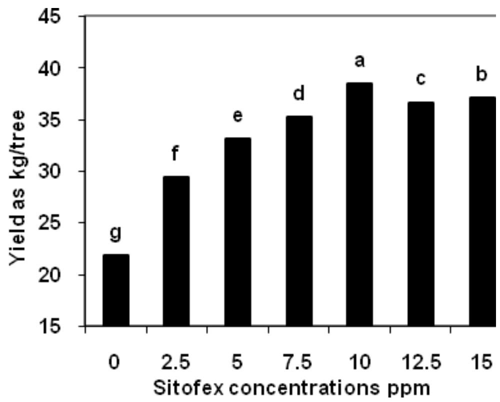

Figure 3: Effect of preharvest sitofex spraying on yield as kg/tree of Kelsey plum trees (average of two seasons).

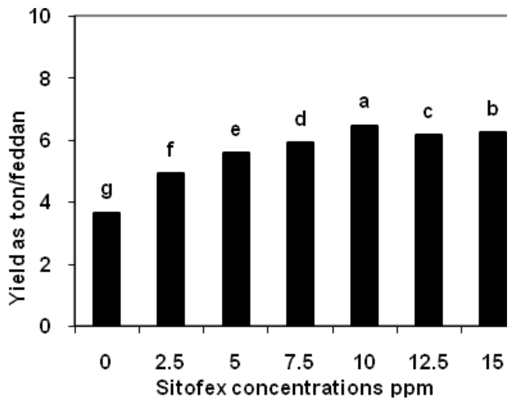

Figure 4: Effect of preharvest sitofex spraying on yield as ton/feddan of Kelsey plum trees (average of two seasons).

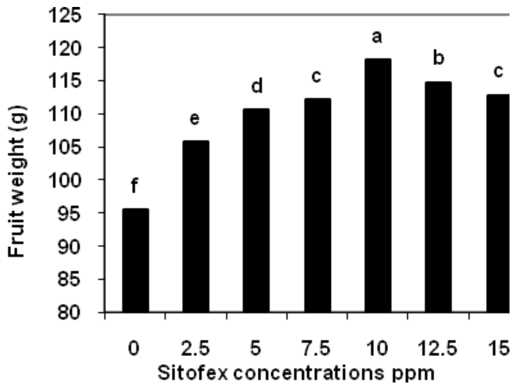

Figure 5: Effect of preharvest sitofex spraying on fruit weight (g) of Kelsey plum trees (average of two seasons).

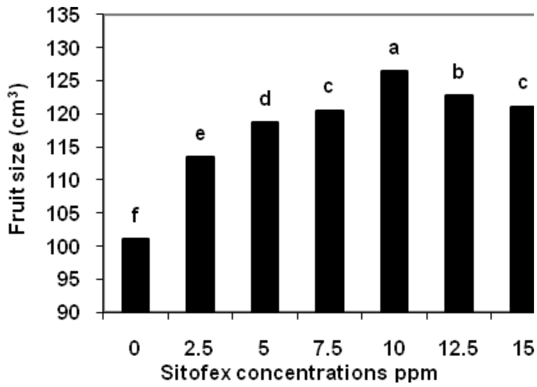

Figure 6: Effect of preharvest sitofex spraying on fruit size (cm^3) of Kelsey plum trees (average of two seasons).

2. Storage ability:

2.1. Fruit weight loss (%):

Data in Table 1 show the effect of preharvest spraying of different concentrations of sitofex on fruit weight loss % of cold stored plum fruits. The results indicated that the percentage of weight loss increased with the progress of storage period in both seasons. The harvested fruits from Kelsey plum trees sprayed with different concentrations of sitofex at full bloom and after two weeks from full bloom and stored under cold storage at 0±1°C with 90 ± 95% RH had lower weight loss percentages as compared to fruits taken from unsprayed trees. Moreover, increasing sitofex concentrations caused significant decrease on percentages of fruit weight loss in both seasons. Foliar application of sitofex at 10, 12.5 and 15 ppm showed to be the superior one in reducing fruit weight loss percentage without significant differences among them in both seasons. So, it can be concluded from the results in Table 1 that, preharvest foliar applications of sitofex (CPPU) were effective in reducing weight loss percentage of Kelsey plum fruits during cold storage. Similar results were obtained by Pujari *et al.,* (2016) on mango. In this respect, Pant (2015) mentioned that, CPPU foliar application reduced physiological loss in fruit weight during storage period compared to the unsprayed ones when used at 10 ppm and sprayed at full bloom and pea stage on Red Delicious apple trees stored at ambient condition for 35 days. Also, Taha and Abd El Ghany (2016) revealed that spraying Anna apple trees with CPPU at10 ppm at full bloom, fruit set and month before harvest had significantly reduced fruit weight loss during storage at 3°C for 12 weeks. The loss of water from fresh fruit after harvest is a serious problem, causing shrinkage and weight loss. The reduction in fruit weight loss as a result of foliar application of sitofex (CPPU) maybe due to reducing evaporation of water, respiration rate, degradive processes and ethylene production during cold storage which reflected on delay the fruit ripening and thereby delay the decline in fruit quality.

Table 1: Effect of preharvest sitofex spraying on fruit weight loss % of Kelsey plum fruits stored at 0 ±1°C with 90 – 95 % RH.

Sitofex concentration (ppm)	Storage period (days)											
	0	7	14	21	28	Mean (A)	0	7	14	21	28	Mean (A)
	2018 season						2019 season					
Control	0.00	1.79	2.66	4.12	4.59	2.63 a	0.00	1.87	2.68	4.17	5.07	2.67 a
2.5	0.00	1.79	2.46	3.09	4.15	2.30 b	0.00	1.72	2.70	2.80	3.23	2.09 b
5.0	0.00	1.15	2.24	2.88	4.05	2.06 bc	0.00	1.06	2.56	2.91	3.29	1.96 bc
7.5	0.00	1.20	2.07	2.60	3.78	1.93 c	0.00	1.26	2.02	2.33	3.53	1.83 bc
10.0	0.00	1.49	1.93	2.73	3.14	1.86 c	0.00	1.22	2.01	2.37	2.98	1.71 c
12.5	0.00	1.26	1.92	2.43	3.84	1.89 c	0.00	1.42	1.87	2.73	3.05	1.81 bc
15.0	0.00	1.25	1.59	2.67	3.80	1.8 c	0.00	1.26	1.58	2.38	3.96	1.83 bc
Mean (B)	0.00 e	1.42 d	2.12 c	2.93 b	3.91 a		0.00 e	1.40 d	2.20 c	2.81 b	3.59 a	
L.S.D. at 5%	Interaction (A × B) = 0.60						Interaction (A × B) = 0.69					

Means followed by different letters are significantly different within means at the P≤0.05 according to L.S.D.

2.2. Fruit decay (%):

The results in Table 2 indicated that spraying sitofex showed an enhancement effect in reducing decays of Kelsey plum fruits during cold storage. Moreover, there is no decayed fruits in any concentration at 7 days of storage, and also spraying sitofex at concentrations of 10, 12.5 and 15 ppm did not show any decayed fruits during storage period at 0±1°C with 90 ± 95% RH for 28 days. Generally, decayed fruits were increased with the prolonging of storage period and the highest decay% was observed in control followed by 2.5,5 and 7.5 ppm sitofex in both seasons, respectively. Whereas, sitofex foliar application at 10, 12.5 and 15 ppm were more effective in preventing fruit decay compared to other treatments in both seasons. These results agreed with Stern et al. (2003) & Taha and Abd El Ghany (2016) on apples. Also, Al Obeed (2012) found that foliar application of CPPU at 5 mg/l improved fruit characteristics such as firmness and vitamin C and reduced fruit decay and weight loss of jujube fruits during storage at 5 °C with 85 ± 90% RH for five weeks.

2.3. Fruit firmness (Newton):

Data presented in Table 3 indicated that fruit firmness was enhanced with all foliar applications of sitofex as compared to control, and also fruit firmness was gradually increased by increasing the concentration of CPPU from 0 to 15 ppm with significant differences among them at harvest time in both seasons. Similar results were reported by Guirguis *et al.* (2010) and Assad (2013) who found that preharvest spraying with CPPU at 5, 10, 15 and 20 ppm enhanced weight, size and firmness of persimmon and plum fruits. During storage the fruits at 0 ±1°C with 90 ± 95% RH, fruit firmness were decreased as storage interval increased. The highest fruit firmness at the end of storage period was recorded with sitofex sprayed at 15 ppm followed by 12.5 and 10 ppm; however the lowest values were noticed in control treatment during the two seasons. The differences were significant among all treatments in both seasons. These findings are in harmony with that of Stern *et al.*, (2003) and Stern *et al.* (2006). They concluded that Royal Gala, Delicious and Golden Delicious apple fruits had no significant decline in fruit firmness and the fruits were 100% healthy after two month cold storage when sprayed at two weeks after full bloom by CPPU at10 ppm. Also, Taha and Abd El Ghany (2016) reported that, CPPU at rate 10 ppm significantly supported Anna apple fruits to maintain the highest fruit firmness during storage for 12 weeks. The positive effect of CPPU as synthetic cytokinin in maintaining firmness might due to reducing or delaying various aspects of maturity by reducing the sensitivity of the fruit to ethylene (Abeles and saltvitjr 1992) whereas, cytokinins and ethylene have opposite effects on the senescence process. In most cases exogenous application of cytokinin counteroct the promotive effects of ethylene on the senescence process (Arteca, 1990). Such conclusions agree with the findings of El Sabagh (2002), Said (2002), on Anna apple and Guirguis *et al.* (2003) on pear fruits.

2.4. Soluble solids content (SSC %):

The results in Figures 7 & 8 revealed that soluble solids content % was significantly decreased with increasing CPPU concentration at harvest time and also during cold storage period in both seasons, especially in concentrations of 10, 12.5 and 15 ppm compared to control. During cold storage, soluble solids content percentage in Kelsey plum fruits significantly increased as storage time progressed. Moreover, the lowest values of SSC % were recorded on CPPU at 15 ppm followed in an ascending order by spraying with 12.5, 10 and 7.5 ppm.

Table 2: Effect of preharvest sitofex spraying on fruit decay % of Kelsey plum fruits stored at 0 ±1°C with 90 – 95 % RH.

Sitofex concentration (ppm)	Storage period (days)											
	0	7	14	21	28	Mean (A)	0	7	14	21	28	Mean (A)
	2018 season						2019 season					
Control	0.00	0.00	0.70	1.47	1.74	0.78 a	0.00	0.00	0.67	1.63	1.79	0.81 a
2.5	0.00	0.00	0.35	1.12	1.22	0.53 b	0.00	0.00	0.40	1.00	1.28	0.53 b
5.0	0.00	0.00	0.00	0.58	0.88	0.29 c	0.00	0.00	0.00	0.69	0.72	0.28 c
7.5	0.00	0.00	0.00	0.41	0.60	0.20 d	0.00	0.00	0.00	0.48	0.51	0.19 d
10.0	0.00	0.00	0.00	0.00	0.00	0.00 e	0.00	0.00	0.00	0.00	0.00	0.00 e
12.5	0.00	0.00	0.00	0.00	0.00	0.00 e	0.00	0.00	0.00	0.00	0.00	0.00 e
15.0	0.00	0.00	0.00	0.00	0.00	0.00 e	0.00	0.00	0.00	0.00	0.00	0.00 e
Mean (B)	0.00 d	0.00 d	0.15 c	0.51 b	0.63 a		0.00 d	0.00 d	0.15 c	0.54 b	0.61 a	
L.S.D. at 5%	Interaction (A × B) = 0.024						Interaction (A × B) = 0.016					

Means followed by different letters are significantly different within means at the P≤0.05 according to L.S.D.

Table 3: Effect of preharvest sitofex spraying on firmness (Newton) of Kelsey plum fruits stored at 0 ±1°C with 90 – 95 % RH.

Sitofex concentration (ppm)	Storage period (days)											
	0	7	14	21	28	Mean (A)	0	7	14	21	28	Mean (A)
	2018 season						2019 season					
Control	6.12	5.17	4.46	4.09	3.12	4.59 g	6.46	5.25	4.70	4.27	3.25	4.78 g
2.5	6.45	5.18	4.60	4.25	3.60	4.84 f	6.71	5.40	4.90	4.32	3.58	4.98 f
5.0	7.14	5.76	4.80	4.45	3.75	5.18 e	7.29	6.18	5.00	4.50	3.65	5.32 e
7.5	7.18	6.11	5.41	4.90	3.82	5.48 d	7.31	6.66	5.14	4.63	3.71	5.47 d
10.0	7.31	6.44	5.55	5.00	4.20	5.70 c	7.45	6.70	5.23	4.64	3.90	5.58 c
12.5	7.44	6.60	5.67	5.12	4.35	5.83 b	7.66	6.70	5.33	4.82	4.17	5.73 b
15.0	7.66	6.77	5.77	5.17	4.62	5.99 a	7.86	6.88	6.69	5.00	4.35	6.15 a
Mean (B)	7.04 a	6.00 b	5.18 c	4.71 d	3.92 e		7.24 a	6.25 b	5.28 c	4.59 d	3.80 e	
L.S.D. at 5%	Interaction (A × B) = 0.13						Interaction (A × B) = 0.08					

Means followed by different letter are significantly different within means at the P≤0.05 according to L.S.D.

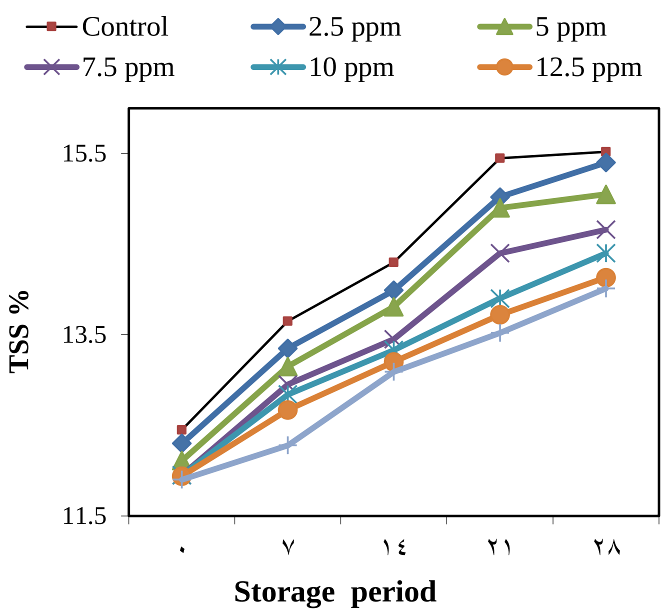

Figure 7: Effect of preharvest sitofex spraying on TSS % of Kelsey plum fruits during cold storage in 2018 season.

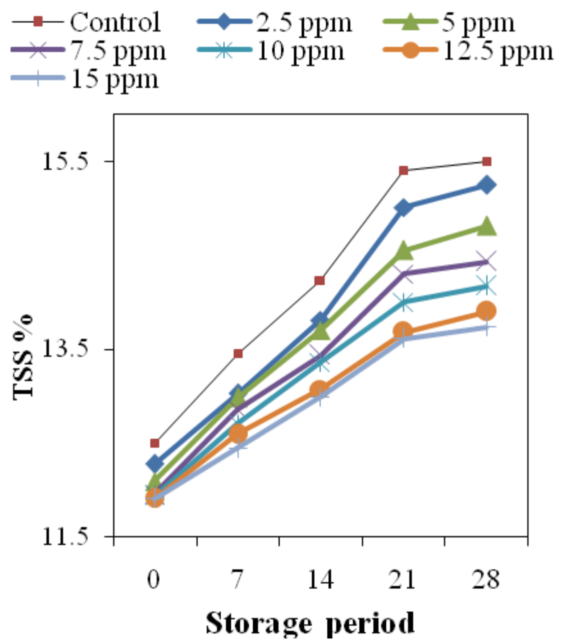

Figure 8: Effect of preharvest sitofex spraying on TSS % of Kelsey plum fruits during cold storage in 2019 season.

While, the highest values of SSC % were recorded in control treatment in both seasons. These results agreed with Reynolds *et al.*, (1992) and Al Obeed (2012). Similar responses were reported by Nasr *et al.* (2009), they found that, CPPU at 10 ppm effectively decreased Le Conte pear fruit weight loss and acidity while increased firmness and TSS after 2 months of cold storage. Also, Taha and Abd El Ghany (2016) revealed that spraying sitofex at 10 ppm reduced fruit weight loss and decay, and increased TSS% as well as maintained fruit firmness of Anna apple fruits during storage at 3°C for 12 weeks. So, it is obvious from the above results, and data in Table 4 that preharvest spraying with sitofex (CPPU) delayed fruit maturity which appeared in the lowest SSC% and highest acidity % as compared to control at harvest date, this effect was continue during cold storage period which reflected on delaying ripening process. This explanation agreed with the findings of Greene (1996) and Stern *et al.* (2003) on 'McIntosh' and 'Royal Gala' apples,; Costa *et al.* (1997) on 'Hayward' kiwifruit; Retamales *et al.* (2014) on 'Duke' blueberry and Pujari *et al.* (2016) on 'Alphonso' mango. Thus, the increase in soluble solids content of fruits as a result of CPPU sprays can be attributed to low levels of the respiration rate, ethylene production and delay in ripening process.

2.5. Titratable acidity percentage:

Data presented in Table 4 showed that, spraying sitofex at different concentrations at full bloom and at two weeks later recorded high levels of titratable acidity in plum fruits at harvest date and during storage period compared to control in both seasons. These results agreed with Ahmed and Abd El Aal (2007) on Le Conte pear and El Sabagh (2002) on apple. In this respect, Guirguis *et al.* (2010) revealed that spraying CPPU at 10 ppm in full bloom and after two weeks from full bloom led to increase acidity in persimmon fruits. Also, Assad (2013) reported that spraying CPPU at 10 ppm after one week of full bloom recorded the highest values of acidity in plum fruits as compared to control fruits. In addition titratable acidity values were significantly decreased with increasing storage period. The highest values of titratable acidity were observed in fruits taken from trees sprayed with 15 ppm sitofex followed by 12.5 and 10 ppm without significant difference among them in both seasons. On the other hand, the lowest content of titratable acidity was observed in control fruits. These results were similar with those reported by Ogata *et al.* (1989), Reynolds *et al.*, (1992) and Nasr *et al.* (2009) they concluded that preharvest spraying with CPPU tended to increase acidity in apple, pear, kiwifruit and grapevine fruits under storage conditions. The titratable acidity is an important factor in maintaining the quality of plum fruits, which is directly related to the organic acids content present in the fruit. Manganaris *et al.*, (2008) reported that the decrease of titratable acidity content could be due to consumption of organic acids in fruits during respiration. According to our results, the treatments of sitofex showed significantly increase in content of titratable acidity than control treatment during storage. So, it seems that sitofex treatments have a positive effect on respiration process which could result in reduction or delay respiration rate and maintain titratable acidity content.

2.6. SSC/acid ratio:

As shown in Figures 9 & 10, significant increases in SSC/acid ratio during storage period at 0±1°C with 90 ± 95% RH were observed in all concentrations of sitofex in the two seasons. Spraying sitofex at different concentrations twice recorded lower levels of SSC/acid ratio in plum fruits than those found in control ones. This decrease in SSC/acid ratio was in proportional with the concentrations of sitofex during cold storage. On the other words, the highest SSC/acid ratio was observed for control treatment, while the lowest one was in 15 ppm CPPU treatment during storage. These results were similar with those reported by Patterson *et al.* (1993) and Nasr *et al.* (2009). Similar response were reported by Taha and Abd El Ghany (2016) who found that spraying sitofex at 10 ppm reduced fruit weight loss and decay, and maintained fruit firmness and TSS/acid ratio of Anna apple fruits during storage at 3°C for 12 weeks. The data in the present experiment showed that high concentrations of sitofex were found to be more effective in delaying maturity in plum fruits at harvest time and reducing ripening process during storage period. These findings were confirmed with Ahmed and Abd El Aal (2007) who revealed that foliar application of sitofex at 10 and 15 ppm were responsible in delaying maturity stage in terms of decreasing total soluble solids % and total sugars % compared to the control. Also, Guirguis *et al.* (2010) and Assad (2013) showed that persimmon and plum trees sprayed with 10 and 15 ppm CPPU tended to delay the date of maturation expressed in the lowest TSS% and the highest acidity% in the juice.

Table 4: Effect of preharvest sitofex spraying on acidity % of Kelsey plum fruits stored at 0 ±1°C with 90 – 95 % RH.

Sitofex concentration (ppm)	Storage period (days)											
	0	7	14	21	28	Mean (A)	0	7	14	21	28	Mean (A)
	2018 season						2019 season					
Control	0.96	0.88	0.82	0.79	0.70	0.83 f	1.00	0.87	0.82	0.76	0.73	0.83 e
2.5	0.96	0.90	0.84	0.80	0.76	0.85 e	1.02	0.89	0.86	0.81	0.78	0.87 d
5.0	1.00	0.91	0.85	0.81	0.78	0.87 d	1.06	0.92	0.87	0.82	0.78	0.89 cd
7.5	1.02	0.93	0.87	0.83	0.80	0.89 c	1.06	0.93	0.87	0.84	0.82	0.90 bc
10.0	1.04	0.93	0.89	0.85	0.82	0.90 b	1.07	0.94	0.90	0.86	0.84	0.92 ab
12.5	1.06	0.95	0.90	0.88	0.84	0.92 a	1.10	0.95	0.92	0.87	0.85	0.93 a
15.0	1.07	0.95	0.91	0.89	0.85	0.93 a	1.11	0.95	0.94	0.89	0.86	0.95 a
Mean (B)	1.01 a	0.92 b	0.86 c	0.83 d	0.79 e		1.06 a	0.92 b	0.88 c	0.83 d	0.80 e	
L.S.D. at 5%	Interaction (A × B) = 0.034						Interaction (A × B) = 0.080					

Means followed by different letters are significantly different within means at the P≤0.05 according to L.S.D.

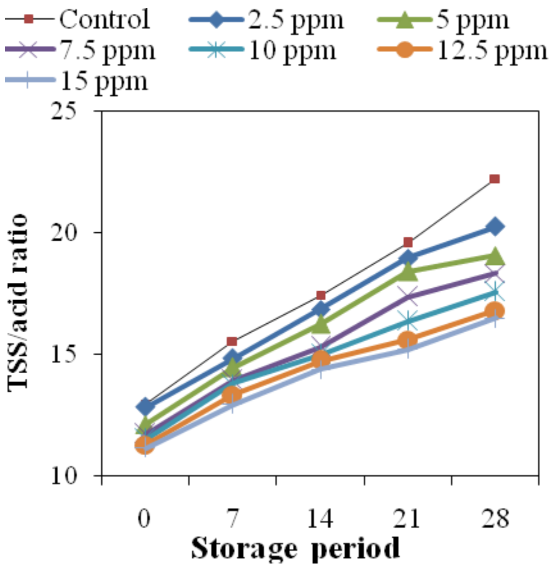

Figure 9: Effect of preharvest sitofex spraying on TSS/acid ratio of Kelsey plum fruits during cold storage in 2018 season.

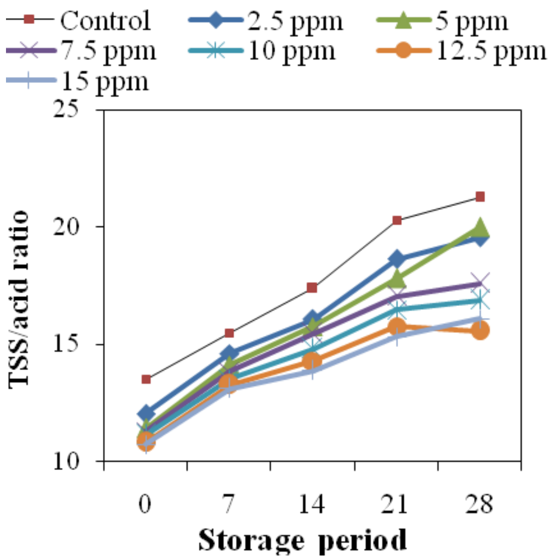

Figure 10: Effect of preharvest sitofex spraying on TSS/acid ratio of Kelsey plum fruits during cold storage in 2019 season.

2.7. Ascorbic acid content:

Data presented in Table 5 cleared that higher concentrations of sitofex foliar sprays produced the highest values of ascorbic acid content at harvest time and during storage period compared other concentrations in the two seasons. Ascorbic acid content in Kelsey plum stored at 0±1°C with 90 ± 95% RH decreased gradually with the progress of storage period. Moreover, fruits from trees sprayed with sitofex had significantly higher value of ascorbic acid content than that on unsprayed trees (control) during storage period in both seasons. The highest ascorbic acid content was observed at 15 ppm followed by 12.5 and 10 ppm CPPU, whereas, control treatment had the lowest value of ascorbic acid compared to other treatments. So, it can be concluded that CPPU foliar application at 10, 12.5 and 15 ppm are most effective in preventing ascorbic acid loss from fruits during storage period, this may be due to its effect in reducing fruit decay, dehydration and delay the decline in fruit quality. The same trend was also observed in the previous study by Al Obeed (2012) who found that foliar application of CPPU at 5 mg/l improved fruit characteristics such as firmness and vitamin C and reduced fruit decay and weight loss of jujube fruits during storage at 5 °C with 85 ± 90% RH for five weeks.

Table 5: Effect of preharvest sitofex spraying on ascorbic acid content (mg/100g fresh weight) of Kelsey plum fruits stored at 0 ±1°C with 90 – 95 % RH.

Sitofex concentration (ppm)	Storage period (days)											
	0	7	14	21	28	Mean (A)	0	7	14	21	28	Mean (A)
	2018 season						2019 season					
Control	6.28	5.78	5.00	4.41	3.89	5.07 f	6.23	5.85	4.73	3.76	3.64	4.83 g
2.5	6.53	6.19	5.29	4.77	4.12	5.36 e	6.46	6.35	5.45	4.95	4.35	5.51 f
5.0	6.84	6.41	5.64	5.14	4.54	5.71 d	6.78	6.53	5.55	5.00	4.45	5.66 e
7.5	7.12	6.73	5.63	5.09	4.78	5.87 c	7.21	6.66	5.85	5.55	5.33	6.12 d
10.0	7.33	6.91	6.15	5.67	5.38	6.28 b	7.45	6.77	6.51	5.65	5.33	6.34 c
12.5	7.35	6.96	6.17	5.72	5.39	6.31 a	7.48	6.85	6.58	5.74	5.41	6.41 b
15.0	7.36	7.00	6.12	5.73	5.42	6.32 a	7.51	6.87	6.69	5.83	5.47	6.47a
Mean (B)	6.97 a	6.56 b	5.71 c	5.21 d	4.78 e		7.01 a	6.55 b	5.90 c	5.21 d	4.85 e	
L.S.D. at 5%	Interaction (A × B) = 0.07						Interaction (A × B) = 0.07					

Means followed by different letters are significantly different within means at the P≤0.05 according to L.S.D.

CONCLUSIONS

It could be concluded that spraying "Kelsey" plum trees with sitofex (CPPU) at 10, 12.5 and 15 ppm significantly increased fruit set, yield and gave the heaviest and largest fruits as well as reduced fruit drop compared to unsprayed trees. Moreover, these three concentrations were the most effective treatments maintaining fruit quality characters during cold storage at 0 ±1°C with 90 ± 95% RH for 28 days. So, it could be recommended that spraying "Kelsey" plum trees with sitofex at 10 ppm twice at the full bloom and two weeks later is considered the best and economic treatment used for enhancing flowering, producing maximum yield with large fruit size as well as maintaining the overall quality of "Kelsey" plum fruits during cold storage.

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الملخص العربى

تأثير الرش الورقي بالسيتوفكس قبل الجمع على المحصول وجودة ثمار البرقوق صنف كلزى أثناء التخزين البارد

حسن أبو الفتوح عناب، مرفت عبد المجيد الشيمى، سامح كامل عقبة
معهد بحوث البساتين – مركز البحوث الزراعية– الجيزة– مصر

تم إجراء هذا البحث خلال موسمي ٢٠١٨ و٢٠١٩ في أبو المطامير– محافظة البحيرة – مصر على أشجار البرقوق صنف كلزى عمرها ثماني سنوات، مطعومة على أصل الماريانا، مسافات الزراعة ٤ × ٥ متر وتنمو فى تربة جيرية تحت نظام الري بالتنقيط. تم رش السيتوفكس (CPPU) بتركيزات ٠ و٢,٥ و٥ و٧,٥ و١٠ و١٢,٥ و١٥ جزءًا في المليون مرتين في قمة التزهير وبعد أسبوعين من الإزهار الكامل لتقييم تأثيرالرش على المحصول وجودة الثمار أثناء التخزين عل درجة حرارة ٠ ± ١ ورطوبة نسبية ٩٠ ± ٩٥ ٪ RH لمدة ٢٨ يوما. أظهرت النتائج أن رش أشجار البرقوق صنف كلزى بالسيتوفكس (CPPU) وبتركيزات ١٠ و١٢,٥ و١٥ جزء في المليون أدي إلى تحسين عقد الثمار وأقل نسبة تساقط للثمار وكذلك إنتاج أعلى محصول سواء كجم / شجرة أو طن / فدان و أعطى ثمار أثقل وزنا ووأكبرحجما. علاوة على ذلك، كانت هذه التركيزات الثلاثة هي الأكثر فاعلية فى الحفاظ على صفات جودة الثمار أثناء التخزين البارد عند درجة حرارة ٠ ± ١ حيث أعطت القيم الأقل فى نسبة الفقد فى وزن الثمار والنسبة المئوية لتدهور الثمار. أيضًا، أعطت هذه التركيزات الثلاثة أعلى درجة من صلابة الثمار وحافظت على محتوى الثمار من نسبة المواد الصلبة الكلية الذائبة والحموضة ونسبة المواد الصلبة إلى الحموضة ومحتوى حمض الأسكوربيك حتى ٢٨ يومًا من التخزين البارد.

وبناء علية، يمكن التوصية بأن يتم رش أشجار البرقوق صنف كلزى بالسيتوفيكس بتركيز ١٠ جزء في المليون مرتين في قمة التزهير وبعد أسبوعين من الإزهار الكامل والذي يعتبر أفضل تركيز إقتصادي يستخدم لتحسين العقد وتقليل تساقط الثماروإنتاج أعلي محصول وتحسين جودة الثمار وخاصة الحجم وكذلك الحفاظ على الجودة الشاملة لثمار البرقوق صنف كلزى أثناء التخزين على درجة حرارة ٠ ± ١ ورطوبة نسبية ٩٠ ± ٩٥ ٪ RH لمدة ٢٨ يومًا.