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Effect of Potassium and Polyamine Sprays on Fruit Set, Fruit Retention, Yield and Fruit Quality of Amhat Date Palm

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ABSTRACT

The present research was accomplished on date palm (*Phoenix dactylifera* L.) cv. Amhat to investigate the effect of potassium citrate and/or putrescine sprays at bloom on fruit set, fruit retention, yield and fruit quality. Treatments were 2% potassium citrate and/or putrescine at 0.045 mM or 0.45 mM. Generally, the higher fruit set%, fruit retention%, bunch weight as well as fruit weight, fruit volume, fruit length, fruit diameter, pulp/seed ratio, also total soluble solids, non reducing sugars, reducing sugars and total sugars values were obtained by spraying mixture of potassium citrate and putrescine (specially at the higher concentration). However, highest titratable acidity and tannins% were obtained from fruits of untreated trees (control), while the lowest values of titratable acidity and tannins% were obtained from mixture sprays of potassium citrate and putrescine. The results of this study proved that potassium and polyamine mixture spraying treatments were more effective than spraying potassium citrate or putrescine individually. Spraying 2% potassium citrate +0.45 mM putrescine at bloom is recommended for improving fruit quantity and quality in date palm cv Amhat.

Key words: Potassium, polyamine, putrescine, fruit set, fruit retention, yield, fruit quality, date palm

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is one of the most important fruit crops in Egypt. The world production of dates according to the recent statistics is about 7533887 metric tons. The Arab countries produce about 5727088 metric tons, which represents about 76% of the total international production. Egypt ranked the first among the date's producers in the Arab countries where it produces about 1352950 metric tons; representing about 18% the world production of dates (FAOSTAT, 2010). Keeping forward this position in view, improved yield and fruit quality of date palm became a main target for many researchers in Egypt. This aim could be achieved through improving fruit set and fruit retention, as well as fruit quality, this could be obtained not only by the application of the proper nutrient element, that involves in increasing fruit set or fruit retention and improving fruit quality, but also the combination with other suitable compounds that positively affect fruit yield and quality parameters. Plant growth stage and timing of fertilizer application affect nutrient uptake (Faust, 1989). In this respect, the main role of potassium is the activation of many enzyme systems involved in the structure of organic substances and promotes photosynthesis and transport of the assimilates of the carbohydrates to the storage organs (Marschner, 1986). In addition, K is involved in several basic physiological functions.

The positive effect of potassium spray on date palm was mentioned by many investigators. Al-Hamoudi (2006) found that spraying 0.4% potassium sulfate on Barhee date palm significantly increased fruit set, yield and improved physical and chemical fruit quality parameters. Similarly, Harhash and Abdel-Nasser (2010) mentioned that spraying "Khalas" date palm bunches at the pre-bloom or bloom stages with 2% K-citrate significantly increased fruit set, yield, improved fruit quality and markedly increased bunches fruit contents of macro and micro-nutrients while leaf contents of macro and micro-nutrients were not affected.

Also, Elsabagh (2012) reported that spraying date palm cv. Deglet Nour Bunches 6 week after polhination with KNO_3 or K_2SO_4 increased retained fruits percentage, fruit weight, fruit size, fruit length and fruit diameter, flesh weight and seed weight compared to the control. However, the same trend was noticed by other investigators, on citrus Yasin *et al.* (2012) mentioned that application of K (0.25% K_2SO_4 solution) was effective in improving fruit set, fruit retention, yield and quality parameters, on olive Hegazi *et al.* (2011) reported that potassium nitrate sprayed twice during the growth season at 4%, enhanced nutritional status, improved vegetative growth, reduced fruit drop and increased the productivity, on mango, Stino *et al.* (2011) concluded that potassium nitrate at 2% sprayed at bud emergence, full bloom and pea stage was one of the most effective treatments in enhancing the yield due to increasing initial fruit set/panicle, fruit retention% fruit, fruit weight and had positive effects on fruit quality as well as physical and chemical fruit properties.

Generally, spraying polyamine (putrescine) at full bloom stage increased fruit set (Boniel and Protacio, 2002).

But, literature on the effect of spraying polyamine alone or combined with potassium on date palm are scant but many investigators studied the beneficial effects of spraying polyamine on other fruit crops such as, Singh and Singh (1995), Boniel and Protacio (2002) and Malik and Singh (2006) on mango, who found that spraying a polyamine (putrescine) at full bloom stage markedly increased fruit set, fruit retention and size of fruits. On apricot, Ali *et al.* (2010) found that spraying10-3 mM putrescine at full-bloom increased yield, fruit weight and fruit volume with significantly higher Soluble Solids Concentration (SSC) SSC/Acidity ratio and lowered fruit acidity. On olive, Ayad *et al.* (2011) mentioned that foliar application of putrescine significantly increased fruit growth characters i.e., size, weight, length and diameter and fruit quality characters i.e. pulp weight and thickness, moisture content, soluble solid content. On jujube trees, Kassem *et al.* (2011) mentioned that foliar sprays of 10 mM putrescine, significantly increased yield, fruit retention, flesh and seed weight, volume, length, diameter, shape index, TSS, V.C, reducing, non-reducing and total sugars, moisture content, fruit chlorophyll a, b and total content and the percentage of fruit grade one (largest fruit), but decreased fruit acidity and carotenoids contents. On apple, Costa and Bagni (1983) mentioned that increases in fruit set; fruit retention and yield have been obtained with polyamines (putrescine, spermidine, spermine). On pear, Crisosto *et al.* (1988) indicated that putrescine applied at anthesis could improve fruit set, crop density, fruit weight, fruit size and yield efficiency, especially under low fruit set conditions.

So, the aim of this study is to investigate the proper combination between polyamine as putrescine at different concentrations and potassium as potassium citrate and their impact on fruit set, fruit retention, yield and fruit quality of Amhat date palm.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2011 and 2012) on 40 years old "Amhat" date palm trees (*Phoenix dactylifera* L.) grown on clay soil at a private orchard located in

El-Badrashin district, Giza Governorate, Egypt. Eighteen palms nearly uniform in size and growth vigor as far as possible were selected and subjected to the same normal cultural practices i.e., pruning, fertilization irrigation etc. Polhination was carried out using the same pollen grains source. The leaf bunch ratio was maintained at 8:1. The number of spathes per palm was adjusted eight bunches by removing earliest, latest and smallest inflorescence for each. The selected palms were divided into 6 treatments in three replicates (each is one palm) and arranged in a randomized complete block design. All treatments were replicated three times where each palm inflorescence per each treatment was sprayed at full bloom with the spraying solution till run off.
The six spraying treatments were as follows:

- Control (water spray only)
- Potassium citrate (K-citrate) at 2%
- Putrescine at 0.045 mM
- Putrescine at 0.45 mM
- Potassium citrate at 2%+Putrescine at 0.045 mM
- Potassium citrate 2%+Putrescine at 0. 45 mM

Fruit samples were collected at ripening stage. The following determinations were carried out:

Fruit set and fruit retention: Initial fruit set and fruit retention percentages were evaluated one month after pollination and at harvested time, respectively. Five female strands per bunch were randomly selected from each replicate. The number of fruit set was recorded and then fruit set percentage and fruit retention were calculated as the following equations:

$$\text{Fruit set (\%)} = \frac{\text{No. of fruits setting on the strand}}{\text{Total No. of flower per strand}} \times 100$$

$$\text{Fruit retention (\%)} = \frac{\text{No. of retained fruits}}{\text{No. of retained fruit+No. of flower scars}} \times 100$$

Yield: was estimated as average bunch weight (kg) for each treatment.

Fruit physical and chemical characteristics: Samples of 30 date fruits were randomly picked from each bunch of all treated palms for determining the physical and chemical properties as following.

Fruit physical characteristics: Fruits of each sample were weighed (g) and measured as length (cm) and diameter (cm) and then the flesh and seeds of the same sample were separately weighed (g). Also fruits of each sample were measured as volume (cm^3) and calculated its specific gravity ($g\ cm^{-3}$).

Fruit chemical characteristics: Total soluble solids% (TSS) in fruit was determined by hand refractometer. Acidity was determined as malic acid percentage (AOAC, 1980). TSS/acid ratio was calculated for each sample.

Fruit sugars and tannins content: Total sugars were determined in the methanol extract using the phenol sulphuric acid method and the percentage was calculated on dry weight basis according to DuBois *et al.* (1956).

Reducing sugars were determined in methanol extract according to AOAC (1995), while non-reducing sugars were calculated as the difference between total sugars and reducing sugars. On the other hand, tannins content was determined in fruits according to the official method described by Winton and Winton (1958).

Statistical analysis: The obtained data were tabulated and statistically using MSTAT-C (MSTAT, 1998) and the significant differences among the probability of 0.05 according to Walter and Duncan (1969).

RESULTS AND DISCUSSION

Fruit set%, fruit retention% and yield (bunch weigh kg^{-1}): Regarding the fruit set and fruit retention percentages and yield as average bunch weight (kg) in response to K and/or putrescine foliar spraying treatments; it is evident from the data presented in Table 1 that K and/or putrescine treatments significantly increased fruit set, fruit retention percentages and yield (Average bunch weigh kg^{-1}) compared with the control in both studied seasons.

Fruit set%: Results cleared that fruit set% obtained by 2% K-citrate (T2) recorded 75 and 75.3%, while those of the control (T1) were 68.2 and 68.9%, in the first and second seasons respectively. The increments in fruit set over than the control were about 10 and 11%, respectively.

With respect to putrescine foliar spray treatments individually, fruit set percentages were 77.0 and 77.7% for putrescine at 0.045 mM (T3) in the first and second seasons, respectively. The increments in fruit set over than the control were about 12.85 and 12.7% respectively. However, the corresponding values for putrescine at 0.45 mM (T4) were 80.2 and 80.3%, representing 17.6 and 16.5% increments over the control, respectively. Literature indicted that foliar applied potassium had a beneficial effects in enhancing the date palm fruit setting (Al-Hamoudi, 2006; Harhash and Abdel-Nasser, 2010; Elsabagh, 2012) on date palm.

However, more increments in fruit set% were obtained by foliar application of mixture solution of K+putrescine (T5 and T6).

Spraying 2% K-citrate+0.045 mM (T5), were accounted fruit set percentages by 80.2 and 80.3% in 2011and 2012 seasons, the increment in fruit set over the control reached about 18 and 19%, respectively.

Similar trend was obtained but to a higher extent was obtained by spraying 2% K-citrate+0.45 mM (T6), where fruit set percentages recorded 82.1 and 84.5% in 2011 and 2012 seasons, respectively. This treatment recorded the highest fruit set percentages compared with all treatments, where the increment in fruit set over the control reached the maximum and attained about 23 and 20% than the control in the first and second seasons, respectively.

Fruit retention%: Table 1 Data, revealed that, the impact of foliar spraying of K and/or putrescine treatments on fruit retention percentages followed the trend obtained on fruit set where, fruit retention% for potassium as 2% K-citrate (T2), attained 45 and 47%, while those of the control (T1), were 39 and 40%, in the first and second seasons, respectively.

Spraying potassium as 2% K-citrate (T2) significantly increased fruit retention percentages than the control by 15.4 and 9.3% in the first and second seasons, respectively.

With respect to putrescine foliar spray treatments, spraying putrescine at 0.045 mM (T3) recorded fruit retention by 49 and 48.3% in the first and second seasons, respectively. However the increments in fruit retention than the control were 25.6 and 30.2%, respectively. The corresponding increments in fruit retention percentages than the control that obtained by putrescine at 0.45 mM (T4) reached 41 and 35% in the first and second seasons, respectively.

However, more significant increments in fruit retention were obtained when 2% K-citrate was combined with putrescine in spraying solution (T5 and T6) specially the higher concentration.

Fruit retention percentages resulted by spraying 2% K-citrate+0. 045 mM (T5), detected 55 and 57%. However, the increments in fruit retention over than the control were about 41 and 42.5% in 2011and 2012 seasons, respectively.

The highest significant fruit retention percentages (60.3 and 62.2%) were obtained by spraying 2% K-citrate+0. 45 mM (T6), the increments in fruit retention than the control represented about 56 and 54% in 2011 and 2012 seasons, respectively. The present results revealed that K has positive effect in increasing retained fruit of date palm. Elsabagh (2012), Stino *et al.* (2011) on mango; Yasin *et al.* (2012), on citrus who suggested that foliar application of K was effective in enhancing the fruit retention per tree.

Yield (bunch weigh kg^{-1}): Fruit yield Bunch\weight (kg) of "Amhat" date palm as affected by potassium and/or putrescine spraying is presented in Table 2. The data indicated that spraying with K and/or putrescine significantly increased fruit yield than the control (in both seasons).

Yield as average bunch weight/kg obtained from palm trees sprayed solely with 2% K-citrate (T2) recorded 12.5 and 14.1 kg. Meanwhile, palm trees sprayed with putrescine at 0.045 mM (T3) yielded (13.2 and 13.7 kg). Similar trend on yield was obtained by spraying putrescine at 0.45 mM (T4) that recorded (13.0 and 15.7 kg). However, the corresponding values for the control detected 11.0 and 12.7 kg in the first and second seasons, respectively.

The increments in yield Bunch\weight (kg) for 2% K-citrate, putrescine at 0.045 mM and putrescine at 0.45 mM (T2, T3 and T4) over the control attained 8.83, 16.76, 19.46% and 11.81, 21.71 and 25.33%, in the first and second seasons, respectively.

Spraying 2% K-citrate+putrescine at 0.045 mM (T5), yielded 15.5 and 16.16 kg. The increment in yield for (T5) over the control attained 40.9 and 27 6%, in the first and second seasons, respectively.

Highest yield bunch/weight kg was obtained from palms sprayed with mixture solution of 2% K-citrate+putrescine at 0.45 mM (T6), yield values detected 16.03 and 17 kg. The increment in yield (bunch weight/kg) for (T6) over the control attained 45.5 and 33.9% in the first and second seasons, respectively.

It's obvious that the impact of spraying putrescine at the high concentration alone or combined with K-citrate was more pronounced on yield than putrescine the low one.

From the obtained results it's obvious that fruit set, fruit retention and yield were enhanced by spraying mixture solution of 2% K-citrate+putrescine at 0.45 mM at bloom in 2011and 2012 seasons (Table 1). Fruit set, fruit retention and yield were increased than the control by about (23, 56 and 34%) and (20, 54 and 46%) in the first and second seasons, respectively. The increment in yield of Amhat date palm in the second season than the first one may be due to the positive effects of potassium and/or putrescine on improving fruit weight.

Table 1: Effect of potassium and putrescine treatments on fruit physical properties of Amhat date palms in two successive Seasons

	Fruit length (cm)		Fruit diameter (cm)		Fruit weight (g)		Fruit volume (cm^3)		Flesh weight%		Seed weight%	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Control	2.90^{e}	3.50^{e}	1.63^{d}	2.13^{ab}	6.50^{d}	8.80^{e}	6.00^{d}	8.83^{d}	81.50$_{d}$	83.20^{c}	18.50^{a}	16.80^{a}
Potassium cit. 2%	3.63^{b}	3.80^{bc}	2.13^{a}	2.20^{ab}	9.33^{b}	10.80^{b}	9.16^{b}	10.40^{b}	80.53^{d}	83.36^{c}	19.46^{a}	16.63^{a}
Putrescine 0.045 mM	3.23^{c}	3.70^{bc}	1.96^{c}	2.06^{b}	8.56^{c}	9.56^{c}	8.56^{c}	8.66^{c}	82.76^{c}	83.80^{bc}	17.23^{b}	16.20^{ab}
Potassium cit. 2%+Putrescine 0.045 mM	3.83^{b}	4.23^{ab}	2.00^{bc}	2.13^{ab}	10.66^{a}	9.66^{c}	10.33^{a}	9.50^{cd}	86.63^{a}	85.86^{abc}	13.36^{d}	13.86^{bc}
Putrescine 0.45 mM	3.76^{b}	3.76^{bc}	2.10^{ab}	2.13^{ab}	10.76^{a}	9.66^{c}	9.93^{a}	9.33^{cd}	84.16^{b}	86.13^{ab}	15.83^{c}	13.86^{bc}
Potassium cit. 2%+Putrescine 0.45 mM	4.63^{a}	4.36$_{a}$	2.03^{abc}	2.36^{a}	10.76^{a}	14.23^{a}	10.50^{a}	14.00^{a}	86.66^{a}	88.23^{a}	13.33^{d}	11.76^{c}
Significance at 5% level	S	S	S	S	S	S	S	S	S	S	S	S

Means having the same letter(s) are not significantly differ at 5% level

Table 2: Effect of potassium and putrescine treatments on some chemical properties of Amhat date palms in two successive

	TSS%		Acidity%		Non reducing sugars%		Reducing sugars%		Total sugars%		Tannins%	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
Control	30.56^{e}	31.66^{cd}	0.48^{a}	0.48^{a}	5.40^{e}	5.56^{e}	25.20^{e}	25.50^{e}	30.60^{d}	31.06^{e}	0.70^{a}	0.63^{a}
Potassium cit. 2%	31.73^{b}	32.33^{bc}	0.45^{ab}	0.43^{ab}	6.30^{b}	6.63^{a}	26.40^{b}	26.86^{b}	32.70^{c}	33.50^{b}	0.60^{b}	0.50^{b}
Putrescine 0.045 mM	31.50^{b}	30.80^{d}	0.44^{ab}	0.42^{b}	6.70^{a}	6.66^{a}	26.36^{b}	26.83^{b}	33.06^{c}	33.50^{b}	0.60^{b}	0.40^{cd}
Potassium cit. 2%+Putrescine 0.045 mM	34.93^{a}	34.23^{a}	0.39^{b}	0.39^{b}	6.86^{a}	6.13^{b}	29.40^{a}	29.93^{a}	35.26^{b}	36.06^{a}	0.50^{c}	0.33^{d}
Putrescine 0.45 mM	32.23^{b}	33.00^{b}	0.43^{ab}	0.42^{ab}	6.43^{ab}	6.70^{a}	26.43^{b}	26.53^{b}	32.86^{c}	33.23^{b}	0.60^{b}	0.46^{bc}
Potassium cit. 2%+Putrescine 0.45 mM	34.40^{a}	34.83^{a}	0.40^{b}	0.39^{b}	6.66^{a}	6.83^{a}	29.53^{a}	29.63^{a}	36.20^{a}	36.50^{a}	0.50^{c}	0.43^{bc}
Significance at 5% level	S	S	S	S	S	S	S	S	S	S	S	S

Means having the same letter(s) are not significantly differ at 5% level

Therefore, spraying 2% K-citrate+0.45 mM putrescine mixture solution was the best treatment to get significant increases in fruit set, fruit retention and fruit yield of date palm cv Amhat.

The present results revealed that putrescine was more effective than K in increasing fruit set fruit retention and fruit yield of date palm and both of K and putrescine have a synergetic effect on all our studied parameters.

Our results proved that the impact of potassium and polyamine mixture spray on yield and fruit quality was more pronounced in yield and fruit quality parameters than spraying each of them solely. However, it seems that both potassium as potassium citrate and polyamine as putrescine mixture spraying solution have a synergetic effect on fruit set, fruit retention and fruit yield depended in our obtained results on polyamine (putrescine) concentration in the spraying solution. Increasing fruit yield due to K spraying may be attributed to its effect in increasing fruit set. These results may gain support from those obtained by Callan *et al.* (1978) and Crisosto *et al.* (1988) who concluded that increasing ovule longevity and fruit set in putrescine treated pear flowers were associated with increased foliar and flower N and B levels after fertilization compared with untreated flowers. Similar findings were supported by Harhash and Abdel-Nasser (2010), Al-Hamoudi (2006), Harhash and Abdel-Nasser (2010) and Elsabagh (2012) on date palm. Boniel and Protacio (2002), Stino *et al.* (2011) on mango, Hegazi *et al.* (2011) on olive, who reported that the enhanced nutritional status of trees improved fruit growth reduced the fruit drop and increased the productivity. This means that the improvement in the nutritional status of N and B in putrescine treated pear flowers (Crisosto *et al.*, 1988) or date palm bunches treated with potassium (Harhash and Abdel-Nasser, 2010) were associated with increased fruit set. This might be attributed to nutrients uptake, thereby improved the fruit set and enhanced many metabolic processes such as carbohydrate transport.

The highest fruit set and fruit retention levels, consequently yield obtained from potassium citrate and putrescine mixture spray treatments may be explained due to adequate total quantities of nutrients available to the flowers as they developed into fruit. This may explain the positive role of putrescine or potassium and polyamine on increasing fruit set. The highest increment in fruit set in Amhat date palm resulted from spraying bunches with potassium and putrescence mixtures spraying solution that could resulted more improvement in flower nutritional status, consequently increased fruit set. In this respect, the beneficial effects of polyamines on fruit set, fruit retention and yield were supported by many investigators, Singh and Singh (1995), Boniel and Protacio (2002), Malik and Singh (2006) on mango; Costa and Bagni (1983), Costa *et al.* (1984) on apple; Crisosto *et al.* (1986, 1988) on pear; Ali *et al.* (2010), on apricot; who found that spraying a polyamine (putrescine) at full bloom stage markedly increased fruit set, fruit retention, yield and size of fruits. This may be explain the highly significant increment in fruit set, fruit retention, yield and fruit quality parameters of Amhat date palmdue to spraying K and putrescine mixture solution.

Fruit physical and chemical characteristics: The effects of K-citrate and/or putrescine spraying treatments on some fruit physical and chemical characteristics of Amhat date palm are presented in Table 3. Spraying K-citrate (T2) increased fruit weight, fruit volume, fruit length and fruit diameter than the control in both seasons, except the increments in fruit length and fruit diameter that lacked significance compared with the control in the second season only. The values of fruit weight, fruit volume, fruit length, fruit diameter and for K-citrate (T2) were (9.33, 9.16, 3.63 and 2.13) and (10.80, 10.40, 3.80 and 2.20), while the corresponding values of the control (T1)

Table 3: Effect of potassium and putrescine treatments on fruit set, fruit retention and bunch weight on Amhat date palm in two successive seasons

	Fruit set (%)		Fruit retention (%)		Bunch weight (kg)	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	68.23^{e}	68.90^{e}	39.00^{e}	40.00^{d}	11.00^{d}	12.66^{d}
Potassium cit. 2%	75.00^{b}	75.33^{d}	45.00^{d}	47.00^{c}	12.46^{c}	14.13^{c}
Putrescine 0.045 mM	77.00^{b}	77.66^{c}	49.00^{c}	48.33^{c}	13.16^{bc}	13.86^{c}
Potassium cit. 2%+Putrescine 0.045 mM	81.00^{a}	82.00^{b}	55.00^{b}	57.00^{b}	15.50^{a}	16.16^{b}
Putrescine 0.45 mM	80.23^{d}	80.33^{b}	55.00^{b}	54.00^{b}	13.46^{b}	15.73^{b}
Potassium cit. 2%+Putrescine 0.45 mM	82.10^{a}	84.50^{a}	60.33^{a}	62.33^{a}	16.03^{a}	17.00^{a}
Significance at 5% level	S	S	S	S	S	S

Means having the same letter(s) are not significantly differ at 5% level

recorded (6.50, 6.00, 2.90 and 1.63) and (8.80, 8.83, 3.50 and 2.13) in the first and second seasons, respectively. Spraying Amhat date palm bunches with 2% K-citrate+0.45 mM putrescine mixture solution (T6) showed the superiority in improving the physical characters in both seasons. Fruit weight, volume, length, diameter and values recorded (10.76, 10.50, 4.63 and 2.03) and (14.23, 14.0, 4.36 and 2.36) in the first and second seasons, respectively. The increments in fruit weight, volume, length and diameter attained the maximum and recorded (65.55, 75.0, 59.65 and 24.5%) and (62.7, 58.55, 24.57 and 10.79) over the control in the first and second seasons, respectively. Therefore, increasing fruit physical characters may be attributed to the improvement of fruit growth and uptake of nutrients that accelerate metabolic processes. The improvement in nutritional status in bunches specially B and K increase the rate of sugar transport to actively growing regions and also in developing fruits Most Potassium and putresine spraying treatments significantly increased TSS%, reducing sugars and total sugars% and decreased acidity and tannins%. Potassium is considered to be functional in the transport of carbohydrates and translocation of sugar. Presence of sufficient amounts of available K causes an increase in metabolism of the plant (Marschner, 1986; Arsher, 1985; Liu *et al*., 2006). Potassium also plays a critical role in the phloem translocation mechanism (Bhandal and Malik, 1988). The impairment of phloem transport under K deficiency may lead to the accumulation of soluble sugar in leaves. This perturbation of carbohydrate metabolism may possibly account for the reduction of citrus fruit size under conditions of K deficiency (Chapman, 1968).

Therefore, increasing fruit physical fruit weight, fruit size and pulp weight increment could be due to improving cell size or cell number by nutrient elements and or may be attributed to the improvement of fruit growth and uptake of nutrients that accelerate metabolic processes. These observations were recorded by Harhash and Abdel-Nasser (2010); Elsabagh (2012) on date palm, since they mentioned that potassium increase the rate of sugar transport to actively growing regions and also in developing fruits. Similar results were obtained by Stino *et al*. (2011) on mango and Yasin *et al*. (2012) on citrus. The positive impact of polyamine spraying on physical and chemical fruit properties were reported by many investigators in fruit crops (Ayad *et al*., 2011) on olive; Ali *et al*. (2010) on apricot; (Kassem *et al*., 2011) on jujube trees who observed that spraying a polyamine (putrescine) increased fruit weight and fruit volume with significantly higher soluble solids concentration (SSC) SSC/acidity ratio and lowered fruit acidity.

CONCLUSION

The results of the present study revealed that both of K and putrescine have a synergetic effect on Amhat date palm studied parameters. It is obvious that the presence of potassium with

polyamine "putrescine " in the spraying solution markedly increased fruit set, fruit retention, yield (bunch weigh kg^{-1}) and improved fruit quality parameters i.e. fruit weight, fruit volume, fruit length, flush%, flush/seed ratio, TSS%, reducing sugars% and total sugars% and decreased acidity and tannins%, which reflected in increasing the nutritional values in fruits.

It is suggested that spraying combination of 2% potassium citrate and 0.45 mM putrescine at bloom is recommended to get significant improvement in quantity and quality of date palm cv Amhat.

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