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Effects of calcium carbonate and potassium silicate on yield and fruit quality of Zaghloul date palm cultivar (*Phoenix dactylifera* L.)

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ABSTRACT

Global warming has already negatively affected on agriculture, recently global warming impacts on horticultural crops in past and future. Therefore, some adaptation techniques to mitigate the effects of global warming have been developed to avoid problems and negative approches for negative impact of global warming. This study was carried out on Zaghloul date palms growing at El-Montazah Garden in Alexandria Governorate, Egypt in order to study the effects of plant protectants as calcium carbonate namely Purshade at (2% and 3%) and potassium silicate at (0.1% and 0.2%) on yield, fruit quality and harvesting date. The treatments were sprayed at four times started in Hababouk stage and ending in the first of Khelal stage (May, June, July and August). The results showed that fruit physical characteristics, except fruit length in the first season and bunch weight were improved by 0.1%, 0.2% potassium silicate (K_2 SiO_3) and 2% Purshade treatments and the differences were being significant among those treatments and 3% Purchade and control treatments. Total sugars %, non reducing sugar % and TSS% were increased with (K_2 SiO_3) at 0.1%, 0.2% and Purshade at 2% treatments, while tannins % was reduced. Spraying the bunches of Zaghloul date palm with (K_2 SiO_3) at 0.1%, 0.2% and Purshade at 2% tended to increase the level of Ca % and Mg %, whereas N %, P % and K % did not statistically vary in this concern. All treatments delayed harvest date in comparison with control.

Key words: Date palm, potassium silicate and calcium carbonate, Zaghloul Cv.

Introduction

Date palm (*Phoenix dactylifera* L.) growing in hot arid regions is generally facing several kinds of environmental stresses which limit tree growth and productivity and negatively affect fruit quality. Zaghloul date cultivar is one of the most important cultivars of the soft dates in North Egypt. Fruit are consumed at "Khelal" stage (red color). The income from "Zaghloul" dates is mainly dependent on fruit quality. The average daily maximum temperatures in leading date growing countries range from 27 to 35ºC and date palms can withstand temperatures as high as 50ºC. Furthermore, date palms have been known to withstand extreme climatic conditions Mohamed (2003).

According to replicated field trials and research studies, improvements in plant health associated with Purshade's reduction of solar stress were an important factor in increasing the productivity and the quality of a broad range of crops grown around the world. Purshade reduce all plant stresses by 20-60% and in turn increase marketable yield and improve fruit quality with larger size and better coloring Bose *et al.,* (2001), Glenn *et al.,* (2001), Radha and Mathew (2007) and Peter (2008).

Purshade is the industry's top-performing organic plant protectant for preventing the damaging effects of solar and water stress for use in organic production. The Purshade (62.5% calcium carbonate by weight) has been engineered to reduce solar stress in crops by protecting the foliage and fruit from damaging ultraviolet (UV) and infrared (IR) radiation while still allowing photosynthesis to occur. Engineered with advanced reflectance technology and based on calcium carbonate, a highly reflective mineral, Purshade has been shown to reduce sunburn damage and minimize overall heat stress. When Purshade is used during periods of high light and temperature extremes, crops have the solar protection needed to better reach their full potential and use available water resources more

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efficiently. Purshade compound containing calcium carbonate as well as this containing aluminum silicate as sunscreen protective film that acts as a superior reflective particle barrier to the harmful effects of solar radiation and water stress Fosket, (1994), Nakasone and Paul (1998) and Chadha and Shikhamany (1999). Foliar spray with potassium silicate showed increased chlorophyll content and plant growth, also induced metabolic changes such as increases in citric acid and Malic acid levels, and decreases in fructose, glucose, sucrose, and myo-inositol contents, also had higher ratios of fatty acid unsaturation in glycolipids and phospholipid and elevated amounts of membrane lipids Wang and Galletta (2008).

Using anti-sunburn compounds containing calcium carbonate and Aluminum silicates for different fruit trees growing under hot-dry climates effectively counteracted the adverse effects of high temperature and UV radiation on yield and fruit quality Kerns and Wright (2000) and Melgarejo *et al.,* (2004). Calcium sprays applied to fruit during the growing season may reduce the incidence of certain fruit disorders and may improve fruit quality.

In Egypt conditions, which characterized with higher temperature during summer periods plantation of early in season maturity date palm.

The objective of this study was to decrease global worming on fruits stress and delay ripening by effect of calcium carbonate (Purshade) or potassium silicate application on palm yield, fruit quality and harvesting date of the most commercially important date palm cultivars namely 'Zaghloul' (mainly consumed at Khelal stage). This study can be applied in Upper Egypt on soft date's cultivars under hot arid climate.

Materials and Methods

The present investigation was conducted during 2014 and 2015 seasons on 17 years old Zaghloul date palm cultivar (*Phoenix dactylifera,* L.) grown at El-Montazah Garden in Alexandria Governorate, Egypt. Twenty five date palms were uniformly selected and were received the regular cultural practices and pollinated from the same male date palms. The experiment was designed as randomized complete block design with five replicates (one palm for each replicate). Following fruit set the crop load was adjusted to 8 bunches per palm.

The selected palms were subjected to the following treatments:

Control: Sprayed with water, spraying potassium silicate (K_2 SiO_3) at 0.1%, 0.2% and spraying Purshade at 2% or 3%.

Potassium silicate (K_2SiO_3): potassium liquid silicon contained 26.6% K_2O and 10.4% SiO_3 Formulated by Central Laboratory of Organic Agriculture.

Purshade: Commercial compound contained 62.5% Calcium carbonate.

The treatments were sprayed four times started in Hababouk stage and ending in first of Khelal stage (May, June, July and August). The treatments were applied by a hand sprayer on bunches.

1. Yield and fruit physical characteristics:

At the end of Khelal stage (full colored at harvest time, before Rutab stage) all bunches on each palm were harvested and total bunch weight was recorded as index to yield/palm. In each replicate, a sample of 20 fruits was randomly collected for determination fruit fresh weight (gm), fruit length and fruit diameter (cm).

2. Harvest date:

The harvest date is calculated from beginning the fruit set from May to the full coloration of the fruit and before Rutab stage.

3. Fruit chemical characteristics:

The percentage of fruit total soluble solids was measured by a hand refractometer. Five grams were taken from the whole fruit (peel and pulp) and extracted in 95% ethyl alcohol total, reducing and non reducing sugars were determined as percentage of fresh weight according to A.O.A.C. (1995)

Soluble tannins were determined in each sample by Swain and Hillis (1959) method. For mineral determination of fruit samples, ten fruit samples from each replicate was taken and washed with tap water, rinsed twice in distilled water and were cut into small pieces with a clean knife, then dried at 70°C to a constant weight. The dried materials were ground with stainless steel rotary knife mill, and 0.3 g of each ground sample was digested with sulfuric acid and hydrogen peroxide according to Evenhuis and De Waard (1980). In this digested solution, total nitrogen and phosphorus were calorimetrically determined using spectrophotometer according to Evenhuis (1976) and Murphy and Riley (1962), respectively. Potassium was determined by a flame photometer. Calcium and magnesium were determined by Perkin Elmer Atomic Absorption spectrophotometer.

Statistical analysis:

The experimental design was randomized complete block design (RCBD) with five replicates. The obtained data were statistically analyzed according to Snedecor and Cochran (1990). Duncan's Multiple Range test effect was used to compare treatment means Duncan (1955).

Results and Discussion

1. Fruit physical properties and bunch weight:

The data presented in Table (1) showed that 0.2 % potassium silicate, 2% and 3% Purshade treatments increased bunch weight in the first season as compared with 0.1% potassium silicate and control treatments and the differences were statistically significant, while in the second season the untreated treatment (control) gave the lowest bunch weight comparing with all other treatments. Similar results were announced by Attra (1999). The promoting effect of $CaCO_3$ and Purshade on yield and grapevines cluster weight was supported by the results of Kerns and Wright (2000), Glenn *et al.,* (2001) and Morsy *et al.,* (2008).

Table 1: Effect of different treatments on some fruit physical properties and bunch weight of Zaghloul date palm during 2014 and 2015 seasons

Treatment	Bunch weight (kg)	Fruit weight (gm)	Fruit diameter (cm)	Fruit length (cm)	No. of days from fruiting
	2014 Season				
Control	15.95b	30.52bc	2.58b	6.23a	159e
Potassium silicate 0.1%	17.80a	30.83abc	2.63b	6.10a	169d
Potassium silicate 0.2%	18.48a	36.33a	2.80a	6.33a	183c
Purshade 2%	18.27a	35.58ab	2.70ab	6.60a	191b
Purshade 3%	10.57c	25.70c	2.35c	6.03a	198a
2015 Season					
Control	16.73b	26.55bc	2.38b	5.98cd	168e
Potassium silicate 0.1%	17.25ab	30.83ab	2.60a	6.25bc	180d
Potassium silicate 0.2%	18.35a	35.08a	2.75a	6.80a	195c
Purshade 2%	17.77ab	33.42a	2.60a	6.55ab	200b
Purshade 3%	11.02c	23.42c	2.35b	5.73d	210a

Values carrying same letter (s) are non significantly different with each other

Concerning the fruit weight and fruit diameter the data in Table (1) showed that 0.2% potassium silicate and 2% Purshade gave the highest values in both seasons and the differences were statistically significant among 0.1 % potassium silicate with 0.2% potassium silicate and control in the first season for fruit weight and all other treatments, except 3% Purshade for fruit diameter. Whereas, in the second season the differences were statistically significant among 0.2% potassium silicate, 2% and 3% Purshade with 0.1% potassium silicate and control for both characteristics.

Purshade and other plant protectants protected fruits from all stresses by leaving a protective powdery film on the surfaces of the fruits Attra (1999). These results are in harmony with those obtained by Melgarejo *et al.,* (2004) and Morsy *et al.,* (2008).

As for the effect of potassium silicate and Purshade treatments on fruit length the data in Table (1) indicated that the differences in fruit length was not big enough to be significant among all

sprayed treatments in first season, while in the second season fruit length was affected with Purshade at 2% that gave the highest value comparing with all other treatments and the differences were statistically significant among them and 0.1 potassium silicate, control and 3% Purshade.

The increase in fruit size after treatments during the depressed period was mainly caused by cell enlargement. The depress period is a function of genetics and environmental factors. The improve in fruit physical characteristics of the experimental date palms as a result of potassium silicate and Purshade treatments could be interpreted on the basis of its capacity in Keeping plants 7 degrees F° cooler by reflecting heat. This reduces stress on the plants and enables basic physiological processes to continue in high temperature when they would normally shut down Adam *et al.,* (1984), Leopold and Kriedermann (1985) and Reiley and Shry (1997).

2. Harvest date:

The effect of potassium silicate and Purshade treatments on fruit harvest date (No. of days from fruiting) in both seasons is presented in (Table 1). Data showed that the harvest date was prolonged by 39, 32, 24 and 10 days in the first season and 42, 32, 27 and 12 days in the second season for 3%, 2%, 0.2% and 0.1% Purshade and potassium silicate, respectively, as compared with the control. This might be attributed to its effect on heat requirements for date palm. Purshade or potassium silicate has been shown to keep plant surfaces 3-6 degrees Celsius cooler than untreated plants, Adam *et al.,* (1984), Leopold and Kriedermann (1985) and Reiley and Shry (1997).

Table 2: Effect of different treatments on some fruit chemical properties Zaghloul date palm during 2014 and 2015 seasons

Treatment	TSS %	Total sugars **%**	Reducing sugars **%**	Non reducing sugars %	Soluble tannin **%**
	2014 Season				
Control	30.30b	32.79bc	6.96a	25.84bc	2.64a
Potassium silicate 0.1%	31.75ab	35.99ab	6.49a	29.49ab	2.31ab
Potassium silicate 0.2%	31.45ab	36.29ab	6.50a	29.79ab	2.47ab
Purshade 2%	33.50a	38.72a	6.69a	32.03a	2.09b
Purshade 3%	29.55b	28.53c	6.38a	22.15c	2.38ab
2015 Season					
Control	29.75bc	30.80ab	6.82ab	23.51ab	3.04a
Potassium silicate 0.1%	32.40ab	27.02ab	6.53b	20.49ab	2.43b
Potassium silicate 0.2%	32.25ab	35.44a	6.47b	28.97a	2.38b
Purshade 2%	33.00a	35.22a	5.64c	29.58a	2.63b
Purshade 3%	29.30c	25.24b	7.29a	18.42b	2.55b

Values carrying same letter (s) are non significantly different with each other

3. Fruit chemical properties:

It is evident from the data in Table (2) that application of potassium silicate at 0.1 and 0.2% and Purshade at 2% Purshade increased TSS in dates fruit and the differences were be significant among 2% Purshade with control and 3% Purshade in both seasons.

Concerning the data in Table (2) the 0.2% potassium silicate and 2% Purshade treatments increase total sugars and non reducing sugars in fruits and the differences were be statistically significant with 3% Purshade and control in the first season. But in the second season the differences were be statistically significant with control only. While the differences between the treatments on reducing sugars in the first season were not be enough to be significant but in the second season 3% Purshade gave the highest value and the differences were be significant with all other treatments except untreated one.

In other hand untreated palms gave the highest value in soluble tannins comparing with all other treatments and the differences were be significant with 2% Purshade in the first season but in the second with all other treatments. The net benefit of using different levels of potassium silicate or Purshade during periods of heat stress and intense light radiation is that more carbohydrates are available to be stored in the fruit. The essential roles of silicon (Si) on promotion growth and fruiting

of Zaghloul date palm might be attributed to the effect of Si in enhancing the tolerance of the trees to all stresses, uptake and transport of water and different nutrients, root development and antioxidant defense systems Gad El- Kareem *et al.,*(2014) and Hattori *et al.,* (2005). These results are in harmony with those obtained by Gad El- Kareem, (2012), Al- Wasfy (2012) and Al- Wasfy (2013).

Table 3: Effect of different treatments on minerals content of Zaghloul date palm fruits during 2014 and 2015 seasons

Treatment	N %	P %	K %	Ca %	Mg %
	2014 Season				
Control	0.83a	0.89a	0.67a	0.59c	0.328d
Potassium silicate 0.1%	0.81a	0.91a	0.68a	0.72b	0.343bc
Potassium silicate 0.2%	0.82a	0.91a	0.68a	0.77b	0.355ab
Purshade 2%	0.82a	0.91a	0.67a	0.82a	0.356ab
Purshade 3%	0.83a	0.89a	0.67a	0.87a	0.359a
2015 Season					
Control	0.84a	0.88a	0.68a	0.60c	0.343b
Potassium silicate 0.1%	0.83a	0.90a	0.70a	0.71b	0.338b
Potassium silicate 0.2%	0.82a	0.90a	0.70a	0.75b	0.360a
Purshade 2%	0.82a	0.91a	0.69a	0.84a	0.360a
Purshade 3%	0.84a	0.90a	0.69a	0.89a	0.359a

Values carrying same letter (s) are non significantly different with each other

It is obvious from the data in Table (3) that no significant differences found among all treatments on fruit content of nitrogen, phosphorus and potassium, in both seasons, while fruit calcium content was increase as level of Purshade increase and the differences were statistically significant in both seasons among Purshade treatments and all other treatments and control. It was not surprising that spraying bunches with elevated levels of Purshade was associated with an apparent increase in fruit calcium. However fruit magnesium content was affected by spraying with potassium silicate at 0.2% and all levels of Purshade and the differences were statically significant between treated and non treated bunches except at 0.1% potassium silicate treatment in second season. These findings due to potassium silicate 0.2% and Purshade delay ripening and so coloration, chlorophyll content in fruits may be cause the high content of magnesium in fruits.

Conclusion:

The results concluded that the application of Purshade at 2% or 0.1 and 0.2% potassium silicate four times started in Hababouk stage and ending in first of Khelal stage (May, June, July and August) of Zaghloul date palm trees during the growing season, increased bunch weight, fruit weight, fruit length, fruit diameter, TSS, Ca and Mg, and decreased soluble tannins. All Purshade and potassium silicate treatments delayed harvesting date as compared to the control. The possibility of regulating harvest period, (late harvest date) to increase late crop at November and December which we can gain high profit, as the price can reach to 2 folds.

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