Middle East Journal of Agriculture Research
ISSN 2077-4605

Volume : 07 | Issue : 01 | Jan.-Mar. | 2018
Pages:12-20

The Promotive Effect of Potassium Silicate and Active Dry Yeast for Improving Yield and Fruit Quality of Khalas Date palm

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Received: 15 Nov. 2017 / Accepted: 08 Jan. 2018 / Publication date: 18 Jan. 2018

ABSTRACT

The objective of the present study is to investigate the promotive effect of spraying Khalas date palm bunches with potassium silicate and active dry yeast on fruit yield and fruit physical and chemical characteristics. The present study was carried out during 2015/2016 growing seasons on 10 years old date palm, "Khalas" cultivar grown on sandy soil with 8x8 meters apart under drip irrigation system at a private orchard located point of 63 kilo meter on Cairo-Alexandria Desert Road. Inflorescences were sprayed at three times; the first was one month after pollination, the second was one month after fruit set and the third was one month before harvest. Spraying treatments were performed as potassium silicate at 0.05 and 0.1% and active dry yeast at 250 and 500 ppm, also combination of potassium silicate at 0.05%+active dry yeast at 250 ppm, and potassium silicate at 0.1%+ active dry yeast at 500 ppm, beside the control treatment (spraying with water only). The present results indicated that all spraying treatments increased yield and improved fruit physical and chemical characteristics as compared with untreated palms. Spraying inflorescences with potassium silicate at 0.1% + active dry yeast at 500 ppm followed by Spraying inflorescences with potassium silicate at 0.05% + active dry yeast at 250 ppm were more effective treatments in enhancing yield and improving fruit quality as well as physical and chemical properties.

Key words: Date palm, fruit yield, fruit quality, potassium silicate, active dry yeast.

Introduction

Date palm (*Phoenix dactylifera* L.) has long been one of the most important fruit crops grown in semiarid and arid- regions. In Egypt, many farmers rely on date palms cultivation and exportation of their fruit. According to FAO (2010), Egypt is considered the leading country among the top ten date producers (1,130,000 tons). 'Khalas' is one of the most commercial and soft fruit cultivars in Egypt. Moreover, major problems face date growers as low annually average of yield and fruit quality. Minerals element especially silicon and potassium have an important role for increasing yield and fruit quality, therefore determination the optimum levels for them is a necessity for date palm fertilization. Foliar application of macro and micro-nutrients is the key for improving fruit set, productivity and quality of fruits, as well as it has a beneficial role in recovery of nutritional and physiological disorders in fruit trees (Lalithya *et al*., 2014).

Silicon (Si) is considered as an excellent growth promoting agent, increases plant growth and stimulates productivity in various crop plants. Furthermore, it's application strengthened the plant biomass, height, and productivity under different stressed conditions (Ahmad *et al*., 2007). It also a growth triggers by providing strength and extensibility to plant cells. It gives strength to the endoderm of the mature basal cells and improves the extensibility of apical cells of the roots; thus Si takes part in contribution of a strong, extensive, and deep root system. However, it is known as a vital element that enhances the potential against abiotic stresses, i.e. salinity, cold, drought, heavy metals, and disease (Mateos-Naranjo *et al*., 2013). In addition, it well known by its contributes in efficient water utilization of plants by improving leaf water potential, transpiration rate, and photosynthesis under

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abiotic stressed conditions (Shen *et al*., 2010). It is also highly associated with osmotic adjustment because it accelerates the accumulation of various organic and inorganic substances like proline , glycine betaine (GB), and antioxidant activities in plants that are subjected to stressed environments (Ahmad and Haddad, 2011). Potassium is considered as an important nutrient for date palm growth and productivity (Al-Kharusi *et al.,* 2009).

Potassium is very important for basic physiological functions, such as the formation of sugars, starch, the synthesis of proteins, cell division, growth, fruit formation and could improve fruit size, flavor and color (Abbas and Fares, 2008). Furthermore, it has been shown to promote plant disease reduction, and potassium stress can increase the degree of crop damage by bacterial and fungal diseases (Holzmueller *et al.,* 2007). Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment, and has the added benefit of supplying small amounts of potassium (Epstein, 1999).

Nowadays, bio-fertilization is considered an important tool to improve yield and fruit quality of fruit trees and it becomes as a positive alternative to chemical fertilizers. It is safe for both human and environment, it was accompanied by the reduction of the great pollution occurred on our environment as well as for producing organic foods for export. Application of bio fertilizers in fruit tree orchard is a production system avoids or largely excludes (Abdelaal *et al.,* 2010). In this respect, active dry yeast is a natural safety bio fertilizer which had a positive effect on fruit trees attributed to its content of different nutrients, proteins, large amount of vitamin B and natural plant growth hormones namely cytokinins, which simulates cell division and enlargement (Fathy and Farid, 1996). It has a role in releasing CO_2 which directly improves photosynthesis (Ferguson *et al.*, 1995) and it has a role in increasing auxin and cytokinins contents (Abou El-Yazied and Maday, 2012). In addition, its effectiveness in improving growth, nutrition status, yield and fruit quality (Hafez, 2001andFayed, 2010).

So, the present study was planned to know the response of foliar application of potassium silicate and active dry yeast on yield and fruit quality of Khalas date palm cultivar.

Materials and Methods

The present study was carried out during 2015 and 2016 seasons on 10 years old Kalas date palm (*Phoenix dactylifera* L.) grown on sandy soil with 8x8 meters apart under drip irrigation system at a private orchard located point of 63 kilo meter on Cairo-Alexandria desert road. The selected palms were healthy, nearly uniform in growth vigor and fruiting and received regular horticultural practices. In addition, pruning was performed to maintain bunch/mature leaves ratio to 1:8, respectively. The number of spathes per palm was edited to 10 bunches by removing excess earliest, latest and smallest inflorescence. Pollination was carried out using the same pollen grain source during both seasons of the study. Twenty one date palms were selected and divided into seven treatments in three replicates (each replicate as one palm) and arranged in a randomized complete block design as follows:

1-Control treatment (sprayed with water only).
2-Spraying inflorescences with potassium silicate at 0.05%.
3-Spraying inflorescences with potassium silicate at 0.1%.
4-Spraying inflorescences with active dry yeast at 250 ppm.
5-Spraying inflorescences with active dry yeast at 500 ppm.
6-Spraying inflorescences with potassium silicate at 0.05% + active dry yeast at 250 ppm.
7-Spraying inflorescences with potassium silicate at 0.1% + active dry yeast at 500 ppm.

When mention the time, all spray treatments were thoroughly applied on inflorescences using hand sprayer (5 liters capacity). Potassium silicate and active dry yeast were sprayed for three times (the first was one month after pollination, the second one month after fruit set and third one month

before harvest). The response of "Kalas" date palms to potassium silicate, active dry yeast and their combinations were evaluated through the following determinations:

Yield kg/palm:

In both seasons, bunches were harvested at the first of September when the fruits reached Khalal stage. The average yield weight /palm and bunch weight were recorded in kilograms.

Fruit physical characteristics:

At the peak of color, fruit were picked at random from each bunch to determine physical properties such as fruit weight (g), fruit dimensions (cm) (Length and diameter), pulp weight (g) and seed weight (g).

Fruit chemical characteristics:

Chemical properties i.e. total soluble solids content (T.S.S.) % was determined using hand refractometer, also percentage of total acidity as gm citric acid / 100gm fruit weight, then T.S.S./Acid ratio was calculated. Reducing sugars %, non-reducing sugars % and total sugars % were determined according to A.O.A.C. (1995).

Statistical analysis:

The obtained data during 2015 and 2016 seasons were subjected to analysis of variance according to Snedecor and Cochran (1990). Means were differentiated using values of (LSD) at 5 % level.

Results

Results given in Table (1) indicate that, yield as kg/ palm was significantly affected by different treatments as compared to control. In general, potassium silicate at 0.1%+ active dry yeast at 500ppm recorded the maximum yield per palm since it was 88.53 and 93.60 Kg during both studied seasons, respectively followed by potassium silicate at 0.05%+ active dry yeast at 250ppm which recorded 84.80 and 89.86 Kg in both studied seasons, respectively. Meanwhile, control treatment recorded the lowest value in this respect, since it was 70.66 and 72.00 kg during first and second seasons, respectively.

Table 1: Effect of spraying potassium silicate and active dry yeast on yield, bunch weight and fruit weight of Khalas date palms during 2015 and 2016 seasons.

Parameters / Treatments	Yield/palm (kg)		Bunch weight (kg)		Fruit weight (g)	
	First season	Second season	First season	Second season	First season	Second season
Control	70.66f	72.00g	8.83f	9.00g	10.60f	10.60g
Potassium silicate at 0.05%	72.53e	74.13f	9.06e	9.26f	11.00e	11.36f
Potassium silicate at 0.1%	75.46d	76.53e	9.43d	9.56e	11.40d	11.70e
Active dry yeast at 250 ppm	80.53c	83.73d	10.06c	10.46d	11.66c	11.96d
Active dry yeast at 500 ppm	84.00b	87.46c	10.50b	10.93c	11.96b	12.26c
Potassium silicate at 0.05%+ active dry yeast at 250ppm	84.80b	89.86b	10.60b	11.23b	12.30a	12.70b
Potassium silicate at 0.1%+ active dry yeast at 500ppm	88.53a	93.60a	11.06a	11.70a	12.50a	12.93a
LSD at 0.05 level	1.82	0.85	0.22	0.10	0.23	0.16

Means having the same letter(s) within each column are not significantly different at 5 % level

On the other hand, the other treatments were in between range. Concerning bunch weight, results in the same table reveal that, all potassium silicate and active dry yeast as well as their combinations had a positive effect on bunch weight as compared with the control. Potassium silicate at 0.1%+ active dry yeast at 500ppm gave the highest bunch weight (11.06 and 11.7 Kg) followed by potassium silicate at 0.05%+ active dry yeast at 250ppm (10.60 and 11.23 Kg) in the first and second seasons respectively. On the other hand, control treatment recorded the lowest bunch weight (8.83 and 9.00 Kg) in both seasons of the study. Moreover, the other treatments were intermediate in this respect. Regarding fruit weight, it can be noticed that, all spraying treatments significantly increased fruit weight as compared with control. In this respect, the best treatment that gave the highest significant fruit weight (12.50 and 12.93 Kg) was potassium silicate at 0.1%+ active dry yeast at 500ppm followed by potassium silicate at 0.05%+ active dry yeast at 250ppm which achieved 12.30and 12.70 Kg in the first and second seasons respectively . Control palms gave the lowest significant fruit weight, where it recorded 10.60and 10.60 Kg consecutively during two seasons of study.

Results in Table (2) indicat that fruit dimensions (fruit length and diameter in cm) were significantly affected by different treatments in both seasons of the study . In general, spraying potassium silicate at 0. 1%+ active dry yeast at 500ppm treatment followed by spraying potassium silicate at 0.05%+ active dry yeast at 250 ppm were achieved higher fruit dimensions (3.60 and 3.60 cm) and (3.53 and 3.50 cm), (2.60 and 2.60 cm) and (2.53 and 2.50 cm) for fruit length and width in the first and second seasons respectively as compared with the other treatments and control ,while the control recorded the lowest value in this respect (3.13,3.26 cm) and (2.33 ,2.30 cm) for fruit length and width in both studied seasons, respectively. With regard to flesh percentage, results in Table (2) reveal that all treatments increased significantly average flesh percentage as compared with the control. Spraying potassium silicate at 0.1%+ active dry yeast at 500ppm followed by potassium silicate at 0.05%+ active dry yeast at 250ppm gave higher significant flesh percentage (92.40, 92.43) and (91.40, 92.13) during both seasons of study, respectively. Meanwhile, control treatment recorded the lowest value in this respect (91.06 and 91.23) in the first and second seasons, respectively. Concerning seed percentage, results show that, control treatment produced the highest seed percentage (8.93 and 8.76) in both seasons of the study. However, potassium silicate at 0.1%+ active dry yeast at 500ppm treatment gave the lowest value in this respect since it recorded 7.60 and 7.56 during both seasons of the study respectively. The other treatments were in between range.

Table 2: Effect of spraying potassium silicate and active dry yeast on fruit dimensions (cm), flesh % and seed % of Khalas date palm during 2015 and 2016 seasons.

Parameters / Treatments	Fruit length (cm)		Fruit diameter (cm)		Flesh (%)		Seed (%)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control	3.16e	3.26d	2.33de	2.30e	91.06c	91.23f	8.93a	8.76a
Potassium silicate at 0.05%	3.26de	3.30d	2.30e	2.30e	91.20bc	91.33f	8.80ab	8.66a
Potassium silicate at0. 1%	3.33d	3.36c	3.36cd	2.36d	91.40bc	91.53e	8.60ab	8.46b
Active dry yeast at 250 ppm	3.36cd	3.40c	2.40c	2.40cd	91.60bc	91.76d	8.40ab	8.23c
Active dry yeast at 500 ppm	3.46bc	3.40c	2.40c	2.43c	91.86ab	91.96c	8.13bc	8.03d
Potassium silicate at 0.05%+ active dry yeast at 250ppm	3.53ab	3.50b	2.53b	2.50b	91.40bc	92.13b	8.60ab	7.86e
Potassium silicate at 0.1%+ active dry yeast at 500ppm	3.60a	3.60a	2.60a	2.60a	92.40a	92.43a	7.60c	7.56f
LSD at 0.05 level	0.11	0.05	0.06	0.05	0.69	0.12	0.69	0.12

Means having the same letter(s) within each column are not significantly different at 5 % level

It is clear from the results in Tables (3) that spraying potassium silicate and active dry yeast either alone or in combinations, significantly resulted in improving fruit chemical properties as well as in terms of increasing fruit T.S.S. %, juice % and TSS / Acid ratio in relative to the control treatment. As for TSS %, the results in Table (3) reveal that using foliar application of potassium silicate at 0.1%+ active dry yeast at 500 ppm followed by potassium silicate at 0.05% + active dry

yeast at 250 ppm in descending order gave better results (31.60 and 31.26) and (30.39 and 31.20) in both seasons of the study respectively. On the other hand, control scored the lowest value in this respect (28.80 and 29.13). With regard to acidity % ,all spraying treatments were reduced total acidity as compared with the control, and lower values in this respect(0.18 and 0.18%) and (0.18 and 0.17%) were obtained by potassium silicate at 0.1%+ active dry yeast at 500 ppm and potassium silicate at 0.05% + active dry yeast at 250 ppm in the first and second seasons, respectively. Meanwhile, control treatment gave the highest value in this respect (0.20 and 0.21%). Regardless TSS/acid ratio, results in the same table show that, a noticeable promotion was observed in TSS/acid ratio owing to use potassium silicate at 0.1%+ active dry yeast at 500 ppm since this treatment recorded 175.57 in the first season, meanwhile in the second one, potassium silicate at 0.05% + active dry yeast at 250 ppm gave 176.70. On the contrary, control treatment recorded the lowest value in this respect which achieved 141.73 and 136.60 in both seasons of the study, respectively.

Table 3: Effect of spraying potassium silicate and active dry yeast on TSS%, acidity and TSS/ acid ratio of Khalas date palm during 2015 and 2016 seasons.

Parameters / Treatments	TSS (%)		Acidity (%)		TSS /Acid ratio	
	First season	Second season	First season	Second season	First season	Second season
Control	28.80g	29.13c	0.20a	0.21a	141.73f	136.60d
Potassium silicate at 0.05%	92.20f	29.43c	0.19b	0.20b	153.67e	147.17c
Potassium silicate at 0.1%	29.66e	29.80bc	0.19b	0.20b	156.13de	149.00c
Active dry yeast at 250 ppm	30.00d	30.50ab	0.19b	0.19c	157.90ed	160.53b
Active dry yeast at 500 ppm	30.40c	30.70 a	0.19b	0.19c	160.00c	161.60b
Potassium silicate at 0.05%+ active dry yeast at 250ppm	30.93b	31.20a	0.18c	0.17d	171.83b	176.70a
Potassium silicate at 0.1%+ active dry yeast at 500ppm	31.60a	31.26a	0.18c	0.18d	175.57a	173.73a
LSD at 0.05 level	0.29	0.79	0.003	0.005	3.61	6.45

Means having the same letter(s) within each column are not significantly different at 5 % level

Results in Table (4) indicate that the differences among the treatments were highly significant as for the effect of different treatments on fruit chemical properties such as non-reducing, reducing and total sugars percentages of Khalas date palm cultivar during both seasons.

Table 4: Effect of spraying potassium silicate and active dry yeast on non-reducing %, reducing and total sugar % of Khalas date palm during 2015 and 2016 seasons.

Parameters / Treatments	Non reducing sugars %		Reducing sugars %		Total sugars %	
	First season	Second season	First season	Second season	First season	Second season
Control	10.33f	11.00f	32.66e	33.66d	43.00g	44.66f
Potassium silicate at 0.05%	11.00c	11.00f	33.00e	34.66c	44.00f	45.66e
Potassium silicate at 0.1%	11.66d	11.86e	33.53d	35.53b	45.20e	47.40d
Active dry yeast at 250 ppm	11.93d	12.43d	33.73d	35.73b	45.66d	48.16c
Active dry yeast at 500 ppm	12.46c	12.66c	34.20c	35.86b	46.66c	48.53c
Potassium silicate at 0.05%+ active dry yeast at 250ppm	13.00b	13.23b	34.73b	36.53a	47.73b	49.76b
Potassium silicate at 0.1%+ active dry yeast at 500ppm	13.50a	13.70a	35.20a	36.96a	48.70a	50.66a
LSD at 0.05 level	0.45	0.17	0.44	0.44	0.36	0.41

Means having the same letter(s) within each column are not significantly different at 5 % level

The lowest percentage of fruit chemical properties were found in control treatment 10.33 and 11.00%, 32.66 and 33.66% and 43.00and 44.66 % for non-reducing, reducing and total sugars percentages during the first and second seasons, respectively. On the other hand, spraying potassium silicate at 0.1%+ active dry yeast at 500 ppm followed by potassium silicate at 0.05% + active dry yeast at 250 ppm recorded the highest value in this respect, since they recorded 13.50 and 13.70, 13.00 and 13.20, 35.20 and 36.96, 34.73 and 36.53. 48.70 and 50.66 and 47.77 and 49.76 for non-reducing, reducing and total sugars percentages during both studied seasons, respectively . Moreover, the other treatments were in between range in this respect.

Discussion

In the present results, the promotive effect of spraying Khalas date palm cultivar with potassium silicate and active dry yeast on yield are in accordance with those found by (El-Awad, *et al.,*1982) and (Badran, *et al.,* 2015) who found that, an increase in the percentage of fruit retention as well as bunch weight and total yield due to silicon spray . Moreover, silicon application was essential for stimulating growth and fruiting of different fruit crops (Abd El- Hameed, 2012; Ahmed *et al.*, 2013 and El- Wasfy, 2013) the previous positive action of silicon on growth characters and yield might be attributed to its important roles in improving plant growth and protecting plant against drought, cold, disease, and fungal attack, alleviating abiotic stress (heavy metals toxicity and salinity) and improving root development , uptake of water and nutrients and plant pigment (Datnoff *et al*., 2007 and Qin and Tian, 2009). As for the role of potassium on yield of date palm, it is a critical element for date palm production since it is involved in plant. Applying potassium in generally improves growth and yield of date palm cultivars (Amro *et al*., 2014 and Awad *et al*., 2014). The increment of yield may be attributed to increase in fruit weight and number of fruits / strand. Potassium may be enhances the carbohydrate accumulation through carbohydrate formation and translocation. These results are in harmony with those found by El Sabagh, (2012) and Amro *et al*., (2014) science, they reported that, translocation of photosynthetic assimilations depended on the concentration of cell potassium. Potassium is involved in controlling cell water content and photosynthetic activity. In addition, the increase in yield/palm of Medjool date palm was attributed to the increase of bunch weight. Furthermore, the beneficial influence of K on the yield might be attributed to their enhancing of many metabolic processes like carbohydrate formation, translocation and accumulation which reflected on yield development (David *et al*., 1998). With regard to the effect of active dry yeast on date palm yield, the obtained results are in harmony with those found by Gobara, (2004) who mentioned that spraying yeast at 0.025 to 0.4%was effective in increasing the bunch weight and yield of Zaghloul date palm. Concerning the effect of potassium silicate and active dry yeast on fruit physical characteristics, as well as bunch and fruit weight, fruit dimension also flesh and seed percentage, the positive effect of potassium spray on date palm was mentioned by many investigates. Spraying 0.4% potassium sulfate on Barhee date palm significantly improved fruit physical quality parameters (Al-Hamoudi *et al*., 2006). Moreover, Harhash and Abdel-Nasser, (2010) reported that, spraying "Khalas" date palm bunches at the pre-blooming or blooming stages with 2% potassium citrate significantly improved fruit quality. Also, El-sabagh, (2012) demonstrated that, spraying date palm cv. Deglet Nour bunches; 6 weeks after pollination with KNO_3 or K_2SO_4 leads to an increment in fruit weight, fruit length and fruit diameter, flesh weight and seed weight compared with control. Therefore, increasing fruit physical properties i.e. fruit weight, fruit size, fruit dimensions and pulp weight increment could be due improving cell size or cell number by nutrient elements and or may be attributed to the improvement of fruit growth and nutrients uptake that accelerate metabolic processes. These observations were in line with Harhash and Abdel-Nasser (2010) and El-sabagh, (2012) on date palm, since they cleared that, potassium increases the rate of sugar transportation to actively growing regions and also development fruits. As for the effect of active dry yeast on fruit physical properties the results are in line with those of El-khayat and Noam, (2013) and Mostafa, (2015) on date palm since they found that spraying active dry yeast greatly improved all fruit physical properties that attributed to higher content of protein and natural plant growth hormones i.e. auxin and cytokinins which enhanced cell division and enlargement that promote the increment of the fruit weight and size as well as hastened the fruit maturation. Regarding

the effect of spraying potassium silicate and active dry yeast on fruit chemical properties (TSS %, Acidity %, TSS / Acid ratio, reducing, non-reducing and total sugar), the results are in line with those obtained by Amro *et al*., (2014) and Awad *et al*., (2014) where spraying potassium generally improves fruit chemical properties of date palm cultivars. The improvement of fruit chemical properties was due to the role of K in activating the enzymes involved in sugar biosynthesis and help in translocation of sugars, also promotes photosynthesis process .As for active dry yeast, The results go in line with Entian and Fröhlich, (1984), Mady, (2009) and Rub *et al.*, (2010) who found that, spraying active dry yeast improved fruit chemical characters .The increment in SCC might be due to conversion of carbohydrate into simple sugars and SCC/acidity ratio might be due to the increase in SCC and the decrease in acid. The enhancing effect of yeast application might be due to secretion of cytokinins that enhance the accumulation of soluble metabolites.

Conclusion

From the current study, it can be concluded that fruit yield and fruit physical and chemical characteristics were improved significantly by foliar application of inflorescences with potassium silicate at 0.1% + active dry yeast at 500 ppm followed by spraying inflorescences with potassium silicate at 0.05% + active dry yeast at 250 ppm. These treatment were the best and the most effective treatments in enhancing yield and improving fruit quality as well as physical and chemical properties.

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