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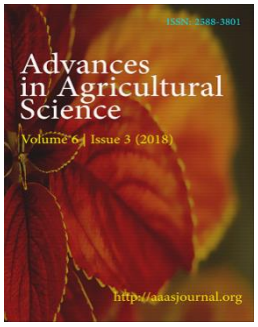

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Effect of foliar spraying with potassium dehydrogenase phosphate and yeast extract on yield and fruit quality of Sukary date palm (*Phoenix dactylifera* L.) in Saudi Arabia

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ABSTRACT

As a natural bio-stimulant, bread yeast has an influence on growth, yield and fruit quality of many crops. This research was conducted during two successive seasons, 2013 and 2014, in order to study the effect of spraying with yeast and potassium dehydrogenase phosphate (KH_2PO_4) on yield, bunch weight and fruit quality of 13 year old Sukary date palm. Five spraying treatments were performed with control (water only), potassium dehydrogenase phosphate at 1 and 2%, and yeast at 4 and 8%. These treatments were applied once at 4 weeks after pollination or twice at 4 week after pollination, repeated after another 4 weeks. All treatments with yeast or potassium dehydrogenase phosphate twice had a pronounced effect compared with the control fruit during both seasons. Spraying Sukary date palms twice with potassium dehydrogenase phosphate (2%) was effective in improving yield, bunch weight and fruit physical characteristics, while spraying yeast (4 and 8%) improved soluble solids content (SSC), and total and reducing sugars.

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Introduction

Saudi Arabia is the largest country of the Arabian Peninsula, occupying about 80% of its area (Abdullah *et al.*, 1998). The country lies between latitudes 16°21'58"' and 32°9'57"' N and longitudes 34°33'48"' and 55°41'29" E (Wynbrandt and Gerges, 2004). Date palm (*Phoenix dactylifera* L.) is one of the most important fruit crops in the Arab world. Arab countries are the main source of dates in the world (Mohamed, 1982).

There are many reports on the effect of nutrient fertilization on date palm yield and fruit qualities (Atalla *et al.*, 1999; Shawky *et al.*,1999). The efficient use of fertilizers is the most important goal in all agricultural systems to improve yield and to reduce the cost (Dong *et al.*, 2005). It is very important to apply a proper fertilization program that matches the requirements of the trees to maximize nutrient uptake and minimize nutrients leaching. The ability of plant leaves to absorb nutrients (Swietlik and Faust, 1984) has resulted in

the efficient uptake of nutrients by fruit trees through foliar rather than soil applications (Weinbaum, 1988).

Potassium (K^+) has a great effect on fruit quality (Geraldson, 1985), since potassium nutrition is directly linked to increased yield, fruit size, shelf life, soluble solids and higher levels of ascorbic acid in many horticultural crops. It is also related to improved fruit color and shipping quality (Usherwood, 1985; Rengel *et al.*, 2008). The impact of yeasts on the production, quality and safety of foods and beverages is intimately linked to their ecology and biological activities (Atawia and El-Desouky, 1997).

Bread yeast (*Saccharomyces cerevisiae*) as a natural bio-stimulant appears to induce growth and yield of many crops, since it has various basic functions including carbon dioxide production, and formation of alcohol, acids and esters (Martinez-Anoya *et al.*, 1990). Spraying Valencia orange trees with active bread yeast either once in March or August or twice in both months improved growth, and fruit set, number, weight and volume, as well as yield and other fruit quality parameters (Hegab *et al.*, 2005). Ahmed *et al.*, (1995) reported similar findings on Picual olive trees. Bio-fertilization is very safe for humans, animals and the environment. It also reduces soil salinity and saves fertilization cost (Fathy and Farid, 1996; Hewedy *et al.*, 1996; Mohamed *et al.*, 1999). The aim of this study was to evaluate the effect of foliar spraying with bread yeast and potassium phosphate on yield and fruit quality of Sukary date palms grown under the conditions of Saudi Arabia.

Materials and Methods

Plant materials and treatments

This research was carried out during two successive seasons, 2013 and 2014, on 13 years old female date palms cv. Sukary, grown at the Agricultural Experimental and Research Station-Dirab, College of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia. Thirty uniform palms (3 palms/treatment for once or twice spraying), grown 10 m apart in sandy soil and subjected to the same management and cultural practices (such as irrigation, pest and weed control, etc.), were selected for this study. Bunches were thinned to 10 per palm and were pollinated from one cv., Meghal male palm by placing 10 fresh male strands among female flower clusters in both seasons.

Bread yeast, the composition of which is shown in Table 1 as reported by Nagodawithana (1991) and mono potassium phosphate (MKP, also potassium dihydrogenphosphate, KDP, or monobasic potassium phosphate, KH_2PO_4- Sigma-Aldrich Canada Ltd) treatments were applied individually by spraying once after 4 weeks of pollination or twice, 4 weeks after pollination and again after a further 4 weeks. Bunches were sprayed (15 litter/tree) using a small motor sprayer, until run-off, with a wetting agent Tween® 20 (1%) added to the spraying solution. Four treatments were applied, 1% potassium phosphate (T_1), 2% potassium dehydrogenase phosphate (T_2), 4% bread yeast (T_3), 8% bread yeast (T_4) and a water only control (T_5).

Main agricultural practices

Fertilization: Nutrients requirements for a sufficient supply with composted organic materials (animal manure with other organic materials like dry leaves of date palm trees and other organic waste material).

Irrigation wells were used in drip irrigation system.

Integrated pest management and bio pesticide were used, bedside using hoeing weeds to get rid of the farm.

Measurements and determination

To determine the total yield at harvest time during Tamr stage, (Tafti and Fooladi 2006), each spathe was weighed separately and the weight was

Table 1. Chemical composition of bread yeast (Nagodawithana, 1991).

Protein	47%	Nucleic acids	8%
Carbohydrates	33%	Lipids	4%
Minerals	8%		
Approximate composition if vitamins (mg/g)			
Thiamine	6-100	Biotin	1.3
Riboflavin	35-50	Collin	4000
Niacin	300-500	Folic acid	5-13
Pyridoxine HCl	28	Vit-B12	0.001
Pantothenate	70		
Approximate composition if minerals (mg/g)			
Na	0.12	Cu	8.00
Ca	0.75	Se	0.10
Fe	0.02	Mn	0.02
Mg	1.65	Cr	2.20
K	21.00	Ni	3.00
P	13.50	Va	0.04
S	3.90	Mo	0.40
Zn	0.17	Sn	3.00
Si	0.03	Li	0.17

Table 2. Effect of potassium phosphate and yeast spraying and number of sprays on fruit weight (g), bunch weight (kg) and yield (kg/tree) of 'Sukary' date palm fruit during 2012 and 2013 seasons.

Treatments	No. of spays	Bunch weight (kg)		Yield (kg/tree)		Fruit weight (g)		Flesh weight (g)	
		2013	2014	2013	2014	2013	2014	2013	2014
KH_2PO_4 1% (T_1)	I	9.67c	11.33f	96.67h	129.33bc	11.37f	12.78e	9.55f	11.06e
	II	10.37c	12.00e	103.67g	120.00bc	12.35e	12.92e	10.46e	11.05e
KH_2PO_4 2% (T_2)	I	14.80ab	16.2b	148.00b	162.00a	15.54a	15.5b	13.64a	13.80b
	II	15.4a	16.67a	154.00a	166.67a	15.72a	16.3a	13.86a	14.51a
yeast 4% (T_3)	I	12.17abc	12.56d	121.67f	129.33bc	13.17d	13.26d	11.27d	11.59d
	II	13.17abc	13.07c	131.67e	130.67bc	13.55c	13.34d	11.75c	11.48de
yeast 8% (T_4)	I	13.57abc	13.46c	135.67d	134.67b	13.85c	13.46d	11.99bc	11.62d
	II	10.77bc	13.47c	141.00c	134.67b	14.26b	14.21c	12.29b	12.46c
Control (T_5)	I	9.17c	10.9f	91.67i	109.00c	10.52g	12.74e	8.74g	11.06e
	II	9.17c	10.9f	91.67i	109.00c	10.52g	12.74e	8.74g	11.06e
LSD 5%		*2.95*	*0.37*	*3.82*	*14.75*	*0.32*	*0.33*	*0.34*	*0.33*

Means followed by a common letter in the same column are not significantly different by LSD (P ≤ 5%)

expressed in kilograms. One hundred fruits per bunch were randomly collected; 50 fruits at Bisir stage (Tafti and Fooladi, 2006) to determine physical characteristics and 50 fruits at Tamr stage to determine chemical characteristics. The fruit lengths and diameters were measured using a digital caliper. Fruit and flesh weight were measured using a digital balance (AOAC, 2000). Fruit volume was measured using the water displacement method. Each fruit was submerged in a container full of water and the volume of displaced water was measured using a 250 cm^3 capacity graduated cylinder. Water temperature during measurements was 27°C (AOAC, 2000). The soluble solids content (SSC), titratable acidity, total soluble sugars, reducing sugars and fruit moisture content were measured to determine fruit quality (AOAC, 2000).

Experimental design and statistical analysis

The experiment was designed as a split plot block model with three replicates (each tree as replicate) per treatment. One way analysis of variance (ANOVA) was performed using the SAS program (SAS, 2000). Means were compared using least significant differences (LSD) at $p \leq 0.05$ (Schanderi 1970).

Results

Bunch weight, yield, fruit weight and flesh weight

Treatment 2 (2%) (Potassium dehydrogenase phosphate) gave significantly the highest bunch weight (2014), yield (2013 and 2014), fruit weight (2013 and 2014) and flesh weight 2013 and 2014, respectively (Table 4). There were non- significant differences among treatments and control in bunch weight (2013), only. Control recorded the lowest significant value in yield (2013), fruit weight (2013) and flesh weight (2013).

Fruit length, diameter flesh weight and SSC

Effects of potassium dehydrogenase phosphate and yeast treatments on some physical characters and SSC percentage during 2013 and 2014 were illustrated in Table 3. Treatment 2 (twice spays) recorded the highest significant values in fruit diameter (2014), while treatment 4 (twice sprays) recorded the highest SSC in both seasons as compared with other treatments during both seasons. There were non-significant differences among treatments in fruit length and fruit volume during both seasons. Control gave the lowest significant fruit length (2014) and SSC content (2013 and 2014).

Acidity, reducing sugars, total sugars and fruit moisture

Control (treatment 5) recorded the highest (0.92 and 0.95%) significant in acidity content at single and twice sprays during 2013 and 2014, respectively, Table 4. While treatment 4 recorded the lowest significant acidity content during 2014. All treatments significantly decreased acidity content compared to the control in both seasons. Treatments 3 and 4 recorded the highest significant reducing sugars during 2013 only. Treatment 2 recorded the highest significant value (17.60%) during 2014 at twice sprays of fruit moisture %. While control recorded the lowest significant reducing sugars (2014), total sugars (2014), respectively and fruit moisture (2014), respectively.

Discussion

Food safety and the link between diet and health are the major concern of the consumer, and yeasts have an important role in this context (Howgate 1998; Massie 2003). Farmers are more interested in using yeasts in Agriculture, as bio control agents, and for the nutrient formation of foods (Fleet 2007); however, food-associated yeasts could be a source of infections and other adverse health responses in humans (Umer *et al.*, 1999). On the other hand, potassium is one of the major macronutrients,

Table 3. Effect of potassium phosphate and yeast spraying and number of sprays on fruit length (cm), fruit diameter (cm), fruit volume (cm^3) and SSC (%) of 'Sukary' date palm fruit during 2012 and 2013 seasons.

Treatments	No. of spays	Fruit length (cm)		Fruit diameter (cm)		Fruit Volume (cm^3)		SSC (%)	
		2013	2014	2013	2014	2013	2014	2013	2014
KH_2PO_4 1% (T_1)	I	3.13b	3.20d	2.65d	2.70c	11.83bc	12.83ab	66.4b	63.20bc
	II	3.17b	3.27cd	2.75c	2.73c	12.33abc	13.00ab	68.80b	64.00bc
KH_2PO_4 2% (T_2)	I	3.22b	3.33bc	3.02a	2.92b	13.00abc	12.83ab	64.80b	62.33c
	II	3.30ab	3.36abc	2.95a	3.02a	13.67abc	13.33ab	65.60b	63.20bc
yeast 4% (T_3)	I	3.22b	3.27cd	2.75c	2.78c	14.17abc	13.93ab	78.8a	64.53bc
	II	3.37ab	3.32bc	2.80bc	2.78c	15.00abc	14.33a	79.2a	64.80b
yeast 8% (T_4)	I	3.45a	3.38ab	2.82bc	2.77c	15.50ab	15.67a	79.2a	65.60b
	II	3.52a	3.45a	2.80bc	2.87b	15.67a	16.33a	79.60a	69.60a
Control (T_5)	I	3.1b	3.10e	2.62d	2.73c	11.33c	12.50ab	60.40c	57.60d
	II	3.1b	3.10e	2.62d	2.73c	11.33c	12.50ab	60.40c	57.60d
LSD 5%		*0.17*	*0.077*	*0.077*	*0.06*	*2.35*	*2.33*	*1.98*	*1.64*

Means followed by a common letter in the same column are not significantly different by LSD (P ≤ 5%)

Table 4. Effect of potassium phosphate and yeast spraying and number of sprays on acidity content (%), reducing sugars (%), total sugars (%) and fruit moisture (%) of 'Sukary' date palm fruit during 2012 and 2013 seasons.

Treatments		Acidity (%)		Reducing sugars (%)		Total sugars (%)		Fruit moisture (%)	
		2013	2014	2013	2014	2013	2014	2013	2014
KH_2PO_4 1% (T_1)	I	0.69bcd	0.63c	34.38c	32.58b	54.34bc	54.34e	14.16de	15.44d
	II	0.78b	0.61c	40.56b	32.62b	54.34bc	56.24cde	14.79de	15.77cd
KH_2PO_4 2% (T_2)	I	0.79b	0.71b	33.24c	35.30ab	53.77bc	54.30e	16.63ab	16.48b
	II	0.76bc	0.63c	36.43bc	35.41ab	58.36b	55.46de	16.96a	17.60a
yeast 4% (T_3)	I	0.68cd	0.61c	48.55a	32.90b	57.00b	57.00cd	14.93d	16.16bc
	II	0.69bcd	0.53d	49.16a	33.24b	58.26b	58.26c	16.01bc	16.21bc
yeast 8% (T_4)	I	0.66d	0.49e	51.27a	34.36ab	70.74a	60.38b	15.79c	14.83e
	II	0.63d	0.45f	48.87a	37.20a	70.75a	64.36a	17.12a	14.51e
Control (T_5)	I	0.92a	0.95a	32.54c	28.46c	50.48c	44.31f	13.91e	14.65e
	II	0.92a	0.95a	32.54c	28.47c	50.48c	44.31f	13.91e	14.65e
LSD 5%		*0.07*	*0.03*	*0.03*	*4.76*	*2.14*	*3.51*	*1.86*	*0.43*

Means followed by a common letter in the same column are not significantly different by LSD (P ≤ 5%)

contributing up to 6% of plant dry weight (Shabala, 2003) and it is considered to be a key factor for fruit quality (Hartz *et al.*, 1999). Results of treatments 4 and 8% yeast (T_3, T_4) had pronounced effect on SSC, total and reducing sugars either one or two sprays (Table 4), while the application of 2% potassium dehydrogenase phosphate (T_2) had a good effect on fruit weight, bunch weight and total yield in both seasons of study (Table 2). All foliar application with yeast or potassium dehydrogenase phosphate at two sprays gets a higher value in most characteristics than one spray during both seasons. These results are in agreed with previous reports (Gobara *et al.*, 2002; Nomier, 2000; Abada, 2002; Abd-Elmotty and Fawzy, 2005; Hossain and Ryu, 2009; Spinelli *et al.*, 2009). Yeast has a beneficial role in improving growth of vegetable (Fathy *et al.*, 2000; Omer, 2003; Sarhan 2008). Abd El-Motty *et*

al., 2010 reported that spraying 'Keitte' mango trees once at full bloom with yeast at 0.2% was very effective in improving yield as number of fruit or fruit weight per tree (kg); increased fruit length (cm), fruit width (cm), fruit weight (g), pulp/fruit percentage; and enhanced total soluble solids (SSC). These effects of yeast extract may be due to that yeast is a natural component (safe and non-pollutant) contains many of the nutrient elements and cytokininis, also has a considerable amounts of amino acids; mineral elements, carbohydrates, reducing sugars, enzymes and vitamins B1, 2, 3, 12 that can improve physical and chemical characters fruit (Fathy and Farid, 1996; Khedr and Farid, 2000). Moreover, it is a source of cytokinins and protein that enhance cell division and enlargement (Barnett 1990). Atawia and El-Desouky (1997) reported that foliar application with natural yeast extract at the full bloom stage of orange 'Washington navel' trees improves the fruit yield per tree as well as fruit quality.

Conclusion

Other approaches have been to try and identify effective natural chemicals, which may be more acceptable to consumers than those that are synthetically produced. Thus, through our results found that spraying bread yeast one time (4 weeks after pollination) or two times (4 weeks after pollination and 4 weeks after the first spray) has a positive effect on yield and fruit quality of 'Sukary' date palm grown under Saudi Arabia conditions.

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