Impact of potassium soil applications on growth attributes and yield of 'Barakawi' date palm (Phoenix dactylifera L.)

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Abstract:

The study was accomplished during seasons 2013 and 2014 at Hezema villages, Karima locality, Northern State, Sudan. The aim of this study is to investigate the impact of Potassium sulphate (K_2SO_4) soil applications on growth attributes, fruit physical traits and yield of "Barakawi" date palm cultivar (Phoenix dactylifera, L.). The selected trees were of uniform growth and size. Four levels of K_2SO_4 treatments were: 0 (control), 50, 100, and 150g/palm applied in the first season only and their extended effects were also considered in the succeeding season. The study was arranged in a randomized complete block design; where each treatment was replicated four times and data were collected at the harvest time in two seasons. The results showed that the soil application of potassium sulphate at 100g/palm increased number of bunches, bunch weight, and yield (kg) of 'Barakawi' date palm. In addition, the treatments tended to enhance growth and fruit physical characteristics compared to the control.

Key words: *Phoenix dactylifera L., 'Barakawi', Potassium Sulphate, Growth, Yield.*

Introduction:

Phoenix dactylifera L. is a dioecious tree, belongs to the family Palmaceae (Arecaceae). Potassium is among the essential macro-elements. It is required for physiological processes such as osmoregulation, enzyme activation, and stomata movement, (Gollback *et al*., 2003) and plays an important role in pH stabilization, protein synthesis, photosynthesis and cell extension (Luchli and Pfluger, 1978), cell divition, cell size, cell number and cell turgidity (Mangel and Kirkby, 2001).This element affects the quantity and quality of dates (El- Deeb *et al.,* 2000). It is accepted that the needs of palm for potassium is high (Klein and Zaid, 2000). One of the most important cultural practices in date palm orchards is fertilization. Proper application of fertilizers can increase quantitative, qualitative and economical output of date production in palm groves (Shaaban and Mahmoud, 2012). However, this application depends on soil texture and uptake rate of fertilizers. In addition the nutrient requirements of the date palms differ greatly within each stage of tree life. Potassium is a critical element for date palm production. The physiological role of potassium is enhancing many metabolic processes such as carbohydrate, formation, translocation and accumulation (Marschner, 1986, Evens and Sorger, 1966). Arsher (1985) reported that translocation of photosynthetic assimilations depends on cell potassium concentration. Potassium is involved in controlling cell water content and photosynthetic activity. Potassium is very important in many ways to productivity of plant and performs important physiological functions (Prajapati and Modi, 2012).

Generally, applying potassium element improves growth, yield and fruit quality of some date palm cultivars. Shahin (2007) on "Khalas", Osman (2010), Dialami and Mohebi (2010) on "Sayer" date palm, Amro *et al*. (2014) on "Hayany", Zagzog and Salem (2016) on "Hayany" date palm and Elsadig *et al*. (2017) on "Khenazi" date palm, recorded that application of different fertilization (N, P, K and S) treatments significantly affected yield component of fruit and total fruit yield per palm. Also Abdi and Hedayat (2010) found that application of mineral nutrients especially potassium, increased yield and quality of fruits in "Kabkab" date palm. Treatments containing potassium decreased the number of faded fruits and bunches and subsequently increasing the yield significantly (Rousta, 2010, Awad *et al.,* 2014) on "Hayany", Elamin *et al.* (2017) found that fruit quality and yield were strongly affected by using N, P, K and organic manure on Khenazi date palm, Abdel-Nasser and El-Shazly (2001) on Picual Olive trees, Ibrahim *et al*. (2013) Found that application of mineral fertilizers, (1.2 or 1.5N, 0.065 or 0.044P and 0.250 or 0.420K) kg/tree increased the number of leaves, bunches per palm, fruit yield and fruit quality. Nasreen (2014) studied combination of fertilizers nutrients (N, P, K and S) on Mango and found that the treatment (N960, P200, K300 and S110) g/tree recorded the highest yield.

Therefore the aim of this study is to investigate the effect of K_2SO_4 soil applications at different levels on growth attributes, yield and fruit physical characteristics of Barakawi date palm cultivar grown under Hezema, condition, Sudan.

Materials and Methods:

The study was accomplished during seasons 2013 and 2014 at Hezema village, Karima locality, Northern State, Sudan, to determine the impact of potassium sulphate soil applications on growth attributes, yield components and fruit physical traits of 'Barakawi' date palm cultivar (*Phoenix dactylifera* L.). Physical and chemical analyses of soil are shown in Appendix (1). The palms were about 30 years old at Hezema and the selected trees were of uniform growth and size. (K_2SO_4) concentrations tested were: 0(control), 50, 100 and 150 g/palm. K_2SO_4 was applied in the first season only by direct application to soil, 50 cm away from the trunk and irrigation followed immediately by direct water pumping from the Nile. The test was arranged in randomized complete block design. Treatments were replicated 4 times. Treatments consisted of 16 date palms. Data were collected at harvest time in September, 2013 and the extended effects of the treatments were also determined in the succeeding season i.e. September 2014. The parameters studied were : Number of leaves/palm; number of leaflets/leaf; length of leaf (cm); length of leaflet (cm); length of strand (cm); number of fruits/strand; fruit length (cm); fruit width (cm); pulp thickness (mm); fruit weight (g); seed length (cm); seed weight (g); number of bunches/palm; bunch weight (kg); yield/palm (kg). The data collected for the different parameters were subjected to analysis of variance and means were separated by Duncan's multiple range test (DMRT) at P =0.05 with the aid of Mstat-C computer program (1990).

Results: Hezema Site:

Vegetative growth attributes:

Table (1) illustrates the results of K_2SO_4 applications on vegetative growth attributes in two successive seasons.100g K_2SO_4 treatment increased the number of leaves per palm significantly over the control, in the first season. In the second season the 150g and 100g K_2SO_4 treatments gave the highest number of leaves with significant increase compared to the control, while the 50g K_2SO_4 treatment was intermediate. In the first season the highly significant difference in leaf length recorded by level 100g K_2SO_4. In the second season, significant increase in this parameter was only achieved from 150g K_2SO_4 treatment, while the other K_2SO_4 treatments ranked intermediate**.** The number of leaflets per leaf in the first season increased only by 50g K_2SO_4 treatment over the control, which statistically equal to the 100 and 150g K_2SO_4 treatments, while in the second season the highest values recorded by 150 and 50g K_2SO_4 treatments. However, the length of leaflets in the two seasons was not affected by K_2SO_4 treatments.

Table (1). Impact of potassium applications on vegetative growth attributes of 'Barakawi' date palm cultivar at Hezema site, seasons 2013 and 2014.

K_2SO_4 (g/palm)	Number of leaves/ palm		Leaf length (cm)		Number of leaflets/ leaf		Leaflet length (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
0	56.00 c	70.00 b	251.3 c	257.5 b	160.5 b	185.0 b	38.75 a	43.75 a
50	69.25 b	78.25ab	263.0 b	277.5ab	186.8 a	197.5 a	39.75 a	45.25 a
100	82.75 a	86.75 a	292.8a	280.0ab	170.8 b	182.5 b	41.50 a	44.25 a
150	63.00 b	91.25 a	264.0 b	286.8 a	160.8 b	206.8 a	40.00 a	45.75 a
C.V %	6.24	11.01	2.18	6.01	4.27	3.10	6.34	5.07

* Means with the same letter (s) in the same column are not significantly different according to DMRT p= 0.05.

Yield components:

As shown in Table (2), the number of bunches per palm, was statistically equal to the control, by all K_2SO_4 treatments, at the two seasons. The length of strand was increased significantly with increasing K_2SO_4 dose in the first season. In the second season all K_2SO_4 treatments increased this parameter significantly over the control, and the highest value recorded by 100g K_2SO_4 treatment. In case of the number of fruits per strand, all K_2SO_4 treatments increased this parameter significantly compared to the control and the highest value was recorded by 100g K_2SO_4 treatment in the two seasons, which was statistically equal to the 50g K_2SO_4 treatment in the first season and to 150g in the second season. Regarding bunch weight, there was highly significant difference between 100g K_2SO_4 and the control and others treatments in the first season. In the second season, all K_2SO_4 treatments increased this parameter without significant difference among them and the highest value recorded by 100 and 150g K_2SO_4 treatments.

Table (2). Impact of potassium applications on yield components of 'Barakawi' date palm cultivar at Hezema site, seasons 2013 and 2014.

K_2SO_4 (g/palm)	Number of bunches/ palm		Length of strand (cm)		Number of fruits/ strand		Bunch weight (kg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
0	11.25 a	7.75 a	32.75 c	28.00 b	5.75 c	18.75 b	1.88 c	3.00 a
50	12.75 a	7.75 a	38.00 bc	38.25 a	15.25 ab	19.50ab	3.03 b	3.00 a
100	12.75 a	8.50 a	51.75 a	42.50 a	16.25 a	21.50 a	3.95 a	3.25 a
150	12.00 a	8.00 a	43.75 b	40.00 a	14.25 b	19.75ab	2.89 b	3.25 a
C.V %	8.46	7.96	9.20	8.02	8.29	7.16	16.37	17.69

* Means with the same letter (s) in the same column are not significantly different according to DMRT p= 0.05.

Yield:

In the first season there were significant differences between treatments, and the highest value was recorded by 100g K_2SO_4 treatment in both seasons, which statistically equal to 150g K_2SO_4 treatment in the second season (Figure 1).

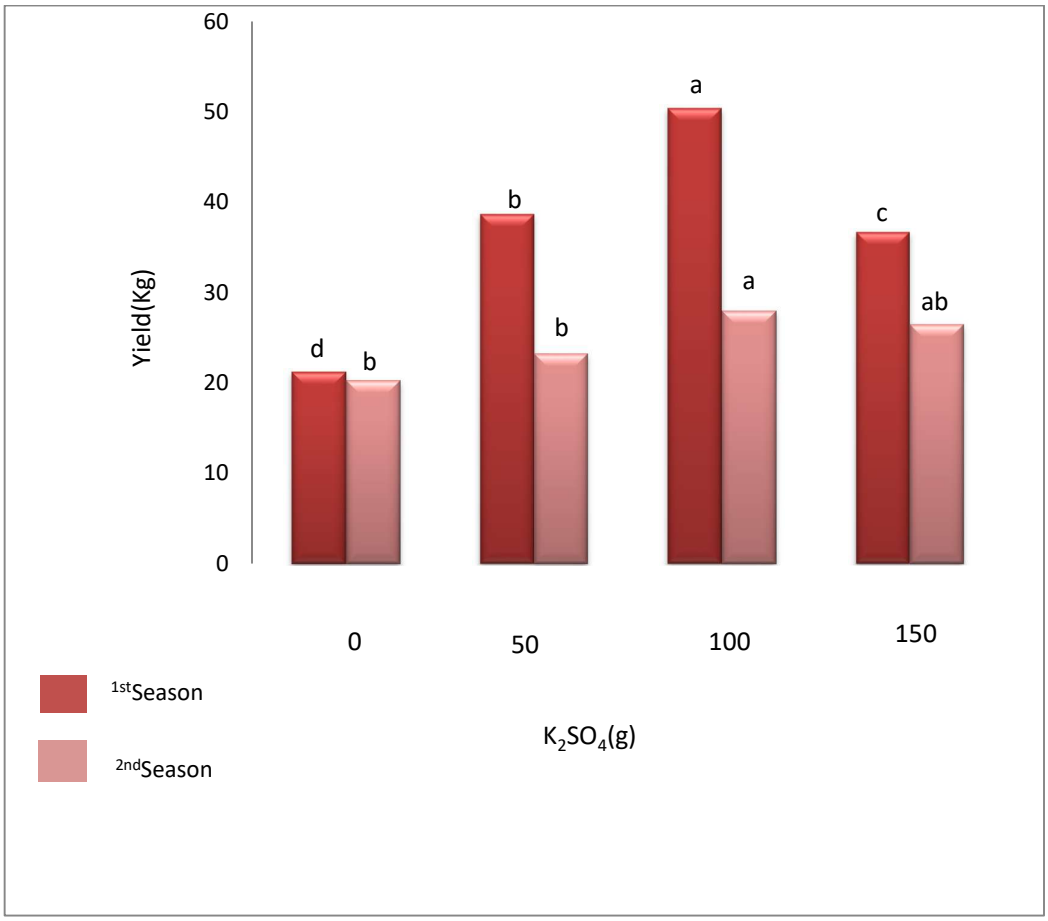

Figure (1). Impact of potassium applications on yield/palm of 'Barakawi' date palm cultivar at Hezema site, seasons 2013 and 2014.

Fruit and seed physical characteristics:

Table (3) illustrated that the increase of fruit length was significantly different from the control and the highest value obtained by 100, 150g K_2SO_4 treatments respectively in the two seasons. The fruit width was not affected by K_2SO_4 treatments in the first season, in the second season the highest values recorded by 50 and 150g K_2SO_4 treatments, which was significantly different from the 100g K_2SO_4 treatment and the control. Pulp thickness in the first season increased significantly over the control by 50g K_2SO_4, while the other treatments ranked intermediate. In the second season only 150g K_2SO_4 treatment recorded the highest value, and significantly different from the control which statistically equal to other treatments. Regarding fruit weight, there was significant increase over the control, the highest value obtained at 150g K_2SO_4 treatment in the two seasons.

Table (3). Impact of potassium applications on fruit physical characteristics of 'Barakawi' date palm cultivar at Hezema site, seasons 2013 and 2014.

K_2SO_4 (g/palm)	Fruit length (cm)		Fruit width (cm)		Pulp thickness (mm)		Fruit weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
0	3.780 c	3.600 c	1.600 a	1.445 c	0.190 b	0.115 b	6.278 b	4.874 d
50	4.412 b	4.415ab	1.640 a	1.830 a	0.252 a	0.120 b	8.040 a	7.203 b
100	4.852 a	4.227 b	1.612 a	1.580 b	0.240ab	0.112 b	7.613 a	5.849 c
150	4.525 b	4.680 a	1.605 a	1.740 a	0.240ab	0.205 a	8.140 a	8.684 a
C.V %	2.77	5.02	3.92	4.05	15.40	12.90	7.78	4.03

* Means with the same letter (s) in the same column are not significantly different according to DMRT p= 0.05.

Results in Table (4) showed that the difference between treatments in seed length, the highest value were obtained by 100 and 150g K_2SO_4 treatments in the first season, also in the second season the highest values were obtained by 150 and 100g K_2SO_4, and the 50g K_2SO_4 treatment was intermediate. Regarding seed weight, there was no significant difference between treatments in the first season. In the second season, only the 50 and 150g K_2SO_4 treatments that shared the top rank were best enhancers of seed weight.

Table(4). Impact of potassium applications on seed physical characteristics of 'Barakawi' date palm cultivar at Hezema site, seasons 2013 and 2014.

K_2SO_4 (g/palm)	Seed length (cm)		Seed weight (g)	
	1st season	2nd season	1st season	2nd season
0	2.210 c	2.400 b	0.962 a	0.801 b
50	2.415 b	2.625 ab	1.001 a	0.940 a
100	2.733 a	2.668 a	1.055 a	0.843 b
150	2.680 a	2.710 a	1.102 a	0.987 a
C.V %	2.07	5.95	16.54	5.08

* Means with the same letter (s) in the same column are not significantly different according to DMRT p= 0.05.

Discussion:

Vegetative growth:

Application of potassium sulphate as shown in Tables (1) tends to increase the number of leaves, length, and number of leaflets; this may be due to increases in photosynthetic efficiency. The present effects may be attributed to the physiological role of potassium in enhancing many metabolic processes such as carbohydrate

formation, translocation and accumulation. (Marchner, 1986; Evens and Sorger, 1966). Potassium is extremely important in many aspects of productivity of plant and promotes important physiological functions (Prajapati and Modi, 2012). These results are in agreement with those found by Ibrahim *et al*. (2013) on "Sewy" date palm, Amro *et al*. (2014) on "Hayany" date palm, Nasreen *et al*. (2014) on mango, Shahin (2007) on "Khalas" and Abdel-Nasser and El-Shazly (2001) on Picual Olive trees.

Yield and yield components:

Application of 100g K_2SO_4 /palm/year tends to increase the number of bunches, number of fruits/strand, bunch weight, yield/palm, and fruit weigh, over the control, Table (2) Figure (1). The increment of number of fruit/strand, fruit weight and bunch weight led to increase of yield. Potassium may be enhancing the carbohydrate formation, translocation and accumulation. These results are in agreement with those of Marschner, (1986), Arsher (1985), Ibrahim *et al*. (2013) on "Sewy" date palm. Elsadig *et al*. (2017) recorded that application of different fertilization treatments significantly affected yield component of fruit and total fruit yield per palm of "Khenazi" date palm, Dialami and Mohebi (2010) on "Sayer" date palm. Abdi and Hedayat (2010) found that application of mineral nutrients especially potassium, increased yield and quality of fruits in "Kabkab" date palm, Osman (2010) on "Batamoda", Awad *et al*.(2014) on "Seweeda" and Zagzog and Salem (2016) on" Hayany"

Fruit and seed physical characteristics:

Application of 100 and 150g K_2SO_4/palm tends to increase fruit weight, fruit width, fruit length, pulp thickness, seed length, and seed weight (Tables 3 and 4) . The increment in fruit physical characteristics may be due to the fact that potassium application plays an important role in pH stabilization, osmoregulation, enzyme activation, protein synthesis, stomata movement, photosynthesis, cell extension, cell division, cell size, cell number and cell turgidity. These results are in line with those obtained by Luchli and Pfluger (1978), Mangel and Kirkby (2001), Gollback *et al*. (2003), Abdi and Hedayat (2010) found that soil application of potassium increased fruit length and diameter on "Kabkab" date palm, Dialami and Mohebi (2010) on "Sayer", Amro *et al.,* (2014) on "Hayany", Zagzog and Salem (2016) on" Hayany" and Elamin *et al*. (2017) found that the fruit quality and yield were strongly affected by using NPK and organic manure on Khenazi date palm.

Conclusion and Recommendation:

From these results and under similar conditions, it could be recommended to fertilize "Barakawi" date palm with potassium sulphate as soil applications at 100 g/palm/year. So, the treatment with small amount of potassium gave the highest yield with good fruit physical traits.

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Appendix (1).Soil physical and chemical analysis at Hezema site, Northern State, Sudan.

Depth Cm	pH	ECe ds/m	Soluble cations (meq/l)			SAR	Soluble anions (meq/l				Sand %	Silt %	Clay %
			Na	Ca+Mg	K		CO_3	HCO_3	Cl	SO_4			
0-30	7.6	1.8	8.7	9.5	0.5	4	Nil	2.8	3	12.9	48	16	36
30-60	7.8	1.3	4.8	8.2	0.1	2	Nil	3.0	2.5	7.6	54	14	32
60-90	8.0	0.99	3.7	7	0.1	2	Nil	2.6	1.2	7.0	36	18	46

Depth Cm	Exchangeable cations Meq/L			P ppm	N %	ESP	SP %	CEC Meq/100g	CaCO3 %
	Na	Ca+Mg	K						
0-----30	1.54	12.96	0.5	4.8	0.03	10	42	15	11
30----60	3.08	20.67	0.25	3.7	0.02	13	44	24	8
60----90	1.98	26.645	0.375	2.8	0.02	7	55	29	8

SP: Saturation percentage **ESP :**Exchangeable Sodium Percentage **SAR :**SodiumAdsorption Ratio.