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Full Length Research Paper

Growth and yield responses of a dry date palm (*Phoenix dactylifera* L.) cultivar to soil and foliar fertilizers

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As date palm culture is concentrated in fertile soils along the banks of the Nile in Sudan, date growers almost neglect dates' fertilization. Related research efforts had been lacking. Complaints of yield decline were frequent in recent years. This broad base-line study was initiated to investigate the influence of single and combined fertilizer treatments on growth and yield of Barakawi, a dry date cultivar under the conditions of the Northern State, Sudan. In complete randomized block design with 5 replicates, N, P, S and Micro elements were tested singly and in combinations in two sites east of Dongola town. The combined treatment of N + P resulted in the most pronounced increments in foliage growth, fruit measures and total yield. The responses to this combination were better than the independent application of each. The result is of practical value as two-folds yield increases were obtained in both sites. Besides, increases gained in fruit measures are considered improvements as large fruits have higher market values. Further optimization studies are needed to develop fertilizer programs for date palms in Sudan.

Keywords: Date palm (*Phoenix dactylifera* L.), fertilizers, growth, fruit, yield.

INTRODUCTION

Date palms are symbols of wealth, social status and they constitute about 70% of exports in the Northern State of Sudan (Dirar, 2003). Date palm culture in Sudan is concentrated in fertile soils along the banks of the Nile; hence growers consider fertilizers application an unnecessary cost. Only urea is applied in date palm orchards when wheat, fodders and vegetables are grown as seasonal under crops (Idris *et al.,* 2006). Within the last 10 years, there were frequent reports on Sudan's dates yield decline, and it has been agreed upon that the decline is attributed to inadequate cultural practices coupled with infestations of pests and diseases (Ali, 2003; Ahmed, 2007; Baghdadi *et al.,* 2003; Idris *et al.,* 2006, 2011; Sidahmed *et al.,* 2009). Date palms require regular fertilization for high stable yield (Al-Bakr, 1972, Hussein and Hussein, 1986a, and Al-rawi, 1998). Al-Dejaili and Al-Dejaili (1989) affirmed the need of date palms for fertilizers especially nitrogen to obtain high numbers of leaves with long green pinnae and high yield. According to Elshurafa (1984), date palm soils lose considerable amounts of macro and micro nutrient elements through leaf pruning and fruit harvest; therefore compensation is necessary. Hence, this study was initiated as a broad baseline study to elucidate the responses of Sudan's major date palm cultivar to the single and combined applications of nitrogen, phosphorous and sulfur soil fertilizers and a micro nutrients foliar spray under the conditions of the Northern State, Sudan.

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MATERIALS AND METHODS

The Northern State of Sudan where this study was conducted is characterized by year round dry conditions

Table 1. Soil physical and chemical properties in site1 and site 2

Parameters	Site 1			Site 2		
	Soil Depth (cm)			Soil Depth (cm)		
	0-30	30-60	60-90	0-30	30-60	60-90
Chemical properties						
pH (paste)	7.68	7.48	7.56	6.73	6.72	7.16
E C (ds/m)	0.45	0.50	0.42	0.36	0.54	0.53
Ca CO_3 %	4.2	4.1	2.0	1.0	1.2	0.8
Na (meq/l)	0.06	0.06	0.06	0.06	0.20	0.20
Ca+Mg (meq/l)	32	41	40	53	37	44
SAR (meq/l)	0.02	0.01	0.01	0.01	0.05	0.04
Physical properties						
Clay %	18	15	9	15	11	13
Silt %	6	6	1	1	1	1
Sand %	76	79	90	84	88	86

as the annual rainfall does not exceed 100 mm; summer is extremely hot (Max. – Min. temperatures: 42-30ºC) and winter is relatively mild (Max. – Min. temperatures: 30-11ºC). This study was carried out during 2009-2010 at two sites on the eastern banks of the Nile, namely at Sileim (site 1) and Kasoura (site 2) that lie 7 km apart opposite to Dongola town. Data on their soil physical and chemical properties is presented in Table 1.

For homogeneity, 8-10 years old fruiting palms were used in both sites. As in surrounding neighboring orchards, no fertilization was practiced since orchards establishment. In complete randomized block design, fertilizer treatments were replicated 5 times where each palm was considered a replicate. Fertilizer treatments were applied once in mid March 2009 after flowering and fruit set. Fertilizer tests were composed of: (N): urea, 500 g/palm (46% N); (P):calcium super phosphate, 200 g/palm (45% super phosphate); (S): granular sulfur, 75 g/palm (80% sulfur); (Micro): a compound micro nutrients foliar solution composed of 0.02% iron, 0.01% of each of manganese, zinc, cupper and boron and 0.005 molybdenum. Each palm received a diluted spray containing 0.6X of actual composition in a total volume of 10 liters to ensure contact with foliage to run-off; (N) + (P); (N) +(S); (N) + (Micro); (P) +(S); (P) + (Micro); Untreated control. (N), (P) and (S) were directly applied in a ditch 50 cm away from base of palm trunks and irrigation followed immediately. At harvest in mid September, data were recorded for the following parameters in the first season: Leaf length, 5 leaves were selected randomly from leaves above fruiting bunches to determine average palm leaf length (cm); Length of leaflets, 2 median leaflets where selected randomly from each leaf used for leaf length determination to compute mean leaflet length (cm); Bunch weight (kg); Fruit weight (g); Fruit length (cm); Fruit width (cm); Pulp thickness (mm). In the second harvest season (September 2010), data were only recorded for bunch numbers and yield/ palm. Recorded data were subjected to analysis of variance for the complete randomized block design and means were separated by Duncan's multiple range tests according to Gomez and Gomez (1984).

RESULTS

The longest leaves in site (1) resulted from single N treatment and the combined N treatments with either S or micro elements. They increase in length was significant compared to the control and the combination of N + P. The rest of treatments ranked intermediate (Table 2). In site (2), the combination N + P increased leaf length significantly compared to other treatments. The N + Micro ranked second without significant difference from N alone. All fertilizer treatments except S increased leaf length significantly over the control (Table 2).

As shown in Table 3, except sulfur, all fertilizer treatments increased the length of leaflets compared to the control in site (1). The longest leaflets resulted from the combination N + P without significant difference from the combination of N + Micro.

A closer pattern was obtained in site (2) as all treatments except sulfur increased length significantly over the control and the combinations N + P and N + Micro ranked top (Table 3).

Table 4 illustrates the effect of fertilizers on bunch weight. In site (1) the highest bunch weights resulted from the combined treatment of N + P which was not significantly different from the single N treatment. All fertilizer treatments increased bunch weight over the control with exception of sulfur. The combination N + P ranked top for bunch weight in site (2) followed by the combination N + Micro, while all other treatments shared a third position with the control.

According to Table 5, all fertilizer treatments increased fruit weight significantly over the control in site (1). The

Table 2. Date palm leaf and leaflet lengths as affected by fertilizer treatments

	Leaf length (cm)		Leaflet length (cm)	
Treatments	**Site 1**	**Site 2**	**Site 1**	**Site 2**
N	291a	267bc	46.20bc	44.80b
S	252ab	235e	41.60fg	40.60ef
P	252b	258cd	42.80ef	43.40bcd
Micro	267ab	250d	43.60e	41.80cde
N + S	283a	257cd	45.20cd	43.60bc
N + P	247b	288a	47.80a	47.80a
N + Micro	290a	275b	47.00ab	46.08a
S + P	268ab	258cd	42.80ef	43.20bcd
S + Micro	274ab	251d	44.00de	41.60de
Control	242b	227e	40.40g	39.60f

*No significant difference between means within column with the same letter at P=0.05

Table 3. Date palm bunch weights as affected by fertilizer treatments

	Bunch weight (kg)	
Treatments	**Site 2**	**Site 1**
N	3.76ab	1.62c
S	2.32de	1.57c
P	3.30b	1.95c
Micro	3.04bc	1.82c
N + S	2.96c	1.79c
N + P	4.28a	3.86a
N + Micro	3.16bc	2.98b
S + P	3.08bc	1.62c
S + Micro	2,85cd	1.66c
Control	2.05e	1.44c

*No significant difference between means within column with the same letter at P=0.05.

Table 4. Weight and length of date palm fruits as affected by fertilizer treatments.

	Fruit length (cm)	Fruit weight (g)		
Treatments	**Site 1**	**Site 2**	**Site 1**	**Site 2**
N	7.30bc	6.90cd	4.80b	4.86bc
S	5.96e	6.38d	4.06de	4.67bcd
P	6.64cde	7.00bc	4.64bc	4.84bc
Micro	6.46de	6.54cd	4.26cde	4.42de
N + S	7.22bc	6.88cd	4.86b	4.52cde
N + P	8.10a	8.84a	5.26a	5.12a
N + Micro	7.40b	7.56bc	4.92ab	4.88bc
S + P	6.66cd	7.78b	4.58bc	5.58a
S + Micro	6.64cde	6.40cd	4.30cd	4.86bc
Control	5.22f	5.96e	3.90e	4.20e

*No significant difference between means within column with the same letter at P=0.05

biggest weights resulted from the combined N and P treatment (Table 5). Similar results were obtained in site (2). In both sites, N + P treatment resulted in significant fruit length increase. In site (1), it shared the top rank with the N + Micro treatment, while it shared position in site (2) with the S +P treatment (Table 5).

Maximum fruit width in site (1) was obtained upon treatment with N + P. Increase in width was significant over all other treatments except the N + Micro and the N + S treatments. In site (2) the biggest fruit width resulted from treatment S + P (Table 6).

Treatments with N + P, N alone and N + Micro in-

Table 5. Width and pulp thickness of date palm fruits as affected by fertilizer treatments

	Fruit width (cm)		Pulp thickness (mm)	
Treatments	**Site 1**	**Site 2**	**Site 1**	**Site 2**
N	4.68ab	4.70bc	3.40ab	3.46cd
S	3.90d	4.62c	2.80cd	3.30cd
P	4.48bc	4.66bc	3.20bc	3.24cd
Micro	4.16cd	4.32cd	3.00bc	3.00de
N + S	4.68ab	4.36cd	3.10bc	3.30cd
N + P	5.08a	4.94b	3.70a	4.40a
N + Micro	4.78ab	4.70bc	3.40ab	4.20a
S + P	4.42bc	5.40a	3.20bc	4.04ab
S + Micro	4.12cd	4.88b	3.20bc	3.46bc
Control	3.68d	4.04d	2.50d	2.70e

*No significant difference between means within column with the same letter at P=0.05.

Table 6. Number of bunches and yield /palm as affected by fertilizer treatments

	No. of bunches/palm		Yield/palm (kg)	
Treatments	**Site 1**	**Site 2**	**Site 1**	**Site 2**
N	16.60a	16.40ab	70.26 b	45.90 c
S	13.80bc	13.80cd	37.22 e	33.52 d
P	16.80a	16.20b	61.16 bc	55.56 b
Micro	15.40b	14.80bc	46.22 de	33.42 d
N + S	14.80b	15.20bc	46.76 de	35.22 d
N + P	17.60a	18.00a	84.12 a	75.24 a
N + Micro	15.60b	17.20a	55.50 cd	53.98 b
S + P	16.60a	17.00a	61.40 bc	54.74 b
S + Micro	13.80bc	15.20bc	41.66 e	34.62 d
Control	10.20d	12.40d	26.10 f	24.02 e

*No significant difference between means within column with the same letter at P=0.05.

creased pulp thickness significantly in site (1). In site (2), the combined N + P and N + Micro treatments resulted in maximum pulp thickness (Table 6).

In the second season, data recorded to study the extended effect of the sole fertilizer treatments in the first season on yield included bunch number and total yield per palm. As illustrated in Table 6, all fertilizer treatments increased the number of bunch per palm significantly compared to the control in site (1). The highest values resulted from N + P, N alone, P alone and S + P treatments. In site (2), all fertilizer treatments increased the number of bunches per palm significantly over the control except the sulfur treatment. The highest gains in bunch number resulted from treatments of N + P, N + Micro, S + P and N alone.

Fertilizer treatments increased yield per palm significantly in the two experimental sites compared to controls (Table 7). The highest yields (almost two fold increase) resulted from N + P fertilizer treatment in both sites.

DISCUSSION

It is noteworthy that sand is the dominant soil constituent in the two experimental sites up to a depth of 90 cm (Table 1). Sand fertility is low, yet date palms extend their root systems several meters within soil in search of water and nutrients to compensate for deficiencies in upper soil strata. According to Furr *et al.,* 1951 and Shabana *et al.,* (1982), the majority of the active date palm roots are concentrated within the top 100 cm soil where most of water-uptake occurs. Hence, good responses to supply of nutrients in this zone are expected. The week response to either sulfur or micro-elements is an indication of adequacy in the non-saline non-sodic soils of the two sites; whereas the beneficial responses to the nitrogen and phosphorous and their combined treatment may owe to inadequacy or unavailability of either element. Nitrogen is the basic protein building unit and protein is the basic cell building unit, and it is involved in numerous physiological processes. Likewise, phosphorous is an essential macro nutrient with structural and functional roles in plant especially flowering attributes, nucleic acids and respiration. Longer leaves and leaflets increase the photosynthetic potency and contribute to the accumulation of carbohydrates; a pre-requisite for ample qualitative yield. The findings of this study support preceding reports of Al-Dijaili and Al-Dijaili (1989), Al-Rawi (1998), Salih and Daoud (2003), who claimed the essentiality of fertilizers especially nitrogen and phosphorous for enhanced growth and yield. They are also of practical value for date growers in Sudan as considerable yield gains were obtained coupled with increase in fruit size that render high market returns.

CONCLUSION

The result of this broad baseline fertilizer study pointed to the need of date palms for fertilization; a practice neglected by growers in Sudan. The encouraging findings validate further research to develop fertilizer programs for date palms under the conditions of the different dates growing states in Sudan.

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