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Response of Two Sesame (*Sesamum indicum* L.) Cultivars to Nitrogen and Phosphorus Fertilization under Rain Fed Conditions*

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Abstract: A field experiment was conducted for two consecutive seasons (2002/2003 and 2003/2004) in the Experimental Farm of the Faculty of Agriculture, University of Sinnar, Abu Naama, Sudan. The objective was to study the response of two sesame (*Sesamum indicum* L.) cultivars to nitrogen and phosphorus fertilization under rain fed conditions. The treatments were four nitrogen levels (0, 40, 80, 120 kgN/ha) and four phosphorus levels (0, 50, 100, 150 kgP_2O_5/ha). Urea (46% N) and triplesuperphosphate (48% P_2O_5) were used as sources of nitrogen and phosphorus, respectively. Two improved sesame cultivars, Khidir and Promo, were used in the study. The experiment was laid out in a split-split plot design with four replicates. Nitrogen treatments were assigned to the main plots, whereas cultivars and phosphorus treatments were allotted to the sub and sub-sub plots, respectively. The results showed that both nitrogen and phosphorus had significant effects on plant height, shoot dry weight, height to the first capsule, capsule number/plant, percentages of capsules on the main stem and the branches and seed yield. The cultivars showed significant differences in some growth and yield attributes, with Promo exhibiting better growth and giving higher yield than Khidir. There was significant interaction between cultivars and nitrogen on seed yield in both seasons.

Key words: Sesame; Khidir; Promo; nitrogen; phosphorus; Sudan

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* Based on the Ph.D. (Agric.) thesis of the first author, the University of Khartoum, Sudan

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INTRODUCTION

Sesame is an important cash crop in Sudan. It is produced mainly by rain, where the uncertainties of rainfall, poor management and traditional low yielding cultivars are the main constraints of production (Weiss 1971). Yields are generally low; the mean yield for the last three decades of the twentieth century was 113, 82 and 72 kg/feddan (1 feddan = 0.42 hectares), respectively, compared with the world mean yield of 185 kg/feddan (Khidir 2007). Application of fertilizers to sesame is rare in the Sudan, because the crop is produced by rains, where the response to fertilizers is not certain due to the uncertainty of the rainy season. Moreover, local cultivars are usually grown, which are adapted to poor soils, and thus show little response to fertilizers (Weiss 1971).

Reports on the response of sesame to fertilizers are conflicting. Saharia and Bayan (1996) showed that application of 45 kgN/ha caused significant increase in growth and yield attributes of sesame. Mitra and Pal (1999) found that sesame yield and yield components significantly increased with nitrogen application up to 100 kgN/ha, but further increase in nitrogen rate depressed yield and yield components. Phosphorus was shown to increase sesame yield by a number of workers. Chaplot *et al.* (1991) found that sesame yield increased with P rate up to 60 kg P_2O_5/ha., while Puste and Maiti (1990) obtained an increase up to 80 kgP_2O_5/ha. However, Prakash and Tandon (2004) indicated that sesame yield was not increased by P even at a rate of 120 kg P_2O_5/ha.

In Sudan, few studies have been carried out on the response of sesame to fertilizers, particularly under rain fed conditions. Gerakis and Tsangarakis (1969) reported that sesame shows positive response to P and N fertilizers in the central clay plain of Sudan. Adam (1987) and Ahmed (1987) also obtained similar result at Abu Naama. However, Ahmed (1987) found no response to N and P fertilizers at El Obied Experimental Station. El Mahadi and Ahmed (2009) reported that nitrogen significantly increased growth, yield and yield components of irrigated sesame in Nile State, northern Sudan.

Recently, two improved cultivars have been released; namely, Khidir and Promo (Ahmed 1998). To realize the high yield potential of such cultivars, improved cultural practices, such as the use of fertilizers, need to be adopted. The present study was, therefore, conducted to investigate the response of these two cultivars to nitrogen and phosphorus fertilization under rain fed conditions.

MATERIALS AND METHODS

A field experiment was conducted for two consecutive seasons (2002/2003 and 2003/2004) in the Experimental Farm of the Faculty of Agriculture, University of Sinnar at Abu Naama, Sudan, to study the response of two sesame (*Sesamum indicum* L.) cultivars to nitrogen and phosphorus fertilization under rain fed conditions. The experimental site lies at latitude 12°44'N and longitude 34°7'E. The area has a tropical climate with a rainy season extending from May to October, with a peak between July and August. Total rainfall was 366 mm and 550 mm for the first and second seasons, respectively. The soil at the site is alkaline (pH 8.5) and contains 58% clay. The treatments were four nitrogen levels (0, 40, 80, 120 kgN/ha) and four phosphorus levels (0, 50, 100, 150 kgP_2O_5/ha). Urea (46% N) and triplesuperphosphate (48% P_2O_5) were used as sources of nitrogen and phosphorus, respectively.

Two improved sesame cultivars, Khidir and Promo, were used in the study. The experiment was laid out in a split-split plot design with four replicates. Nitrogen treatments were assigned to the main plots, whereas cultivars and phosphorus treatments were allotted to the sub and sub-sub plots, respectively. The crop was sown on 15th July in each season, and the fertilizer treatments were applied at sowing. Plant height, shoot dry weight and height to the first capsule were measured at fruit setting, using a sample of five plants randomly chosen from the outer two rows of each plot. Number of capsules/plant, percentages of capsules on the main stem and branches and seed yield were determined from a pre-marked area of 12.6 m^2 in the centre of each plot. The data were subjected to analysis of variance, and means separation was according to the Duncan's Multiple Range Test (Gomez and Gomez 1984).

RESULTS

Vegetative growth

Nitrogen produced consistent increase in plant height in both seasons, but the increase was significant in the first season only; the highest two nitrogen levels (80 and 120 kgN/ha) produced similar and significantly taller plants than the other nitrogen levels (0 and 40 kgN/ha). Plant height was significantly increased by phosphorus in the second season, whereby all phosphorus levels resulted in similar and significantly taller plants than the control. The cultivars showed significant differences in plant height; Promo was significantly taller than Khidir in both seasons (Table 1).

Nitrogen significantly increased shoot dry weight in the first season. All nitrogen levels showed similar but significantly higher shoot dry weights than the control. Phosphorus also significantly increased shoot dry weight in the second season, all phosphorus levels resulted in similar but significantly greater shoot dry weight than the control. Promo had significantly higher shoot dry weight than Khidir in the first season, and the reverse was true in the second season (Table 1).

Height to the first capsule was significantly increased by nitrogen in both seasons. In the first season, the greatest first capsule height was at the intermediate nitrogen level (80 kgN/ha), whereas in the second season all nitrogen levels gave similar but significantly greater first capsule heights than the control. Phosphorus significantly increased the height to the first capsule in the second season only; the highest phosphorus level (150 kg P_2O_5/ha) resulted in the greatest plant height to the first capsule. Promo showed greater height to the first capsule than Khidir in both seasons (Table 1).

Yield and yield components

Nitrogen significantly increased the number of capsules/plant in both seasons; all nitrogen levels produced similar but significantly higher capsule number than the control. Likewise, phosphorus caused a significant increase in the number of capsules in both seasons, and all phosphorus levels had similar but significantly higher capsule number than the control. Promo gave non-significantly higher capsule number than Khidir in both seasons (Table 1).

Table 1. Effects of nitrogen and phosphorus on plant height shoot dry weight, height to the first capsule and number of capsules/plant

Treatment	Plant height (cm)		Shoot dry weight(g)		Height to the first capsule (cm)		Number of capsules/plant	
	I	Π	I	Π	I	Π	I	Π
N (kgN/ha)								
0	78.5c	129.0a	78.6b	22.9a	35.8c	58.9b	51.9b	54.9b
40	83.4b	133.9a	120.2a	28.1a	46.2b	63.9a	67.7a	69.5a
80	92.1[a]	136.0a	128.2a	30.2a	50.7a	65.5a	65.8a	66.8a
120	91.4[a]	133.2a	110.0a	29.9a	46.8b	63.7a	67.5a	68.5a
P(kgP_2O_5/ha)								
0	86.4[a]	129.8b	101.8a	23.9b	44.9a	60.3c	57.8b	59.2b
50	86.3[a]	133.5a	118.3a	27.5a	44.5a	62.7b	64.4a	67.0a
100	85.4[a]	133.5a	110.6a	28.9a	45.4a	63.3b	65.1a	66.3a
150	87.2[a]	135.3a	106.3a	30.9a	44.7a	65.7a	65.7a	67.2a
Cultivars								
Khidir	83.3[a]	130.9a	101.8a	29.7a	43.4a	61.4a	61.8a	64.2a
Promo	89.5b	135.1b	116.7b	25.8b	46.3b	64.6b	64.7a	65.7a
S.E. ± for N	1.34	2.61	7.02	2.59	0.98	0.99	1.94	1.75
S.E. ± for P	1.34	1.07	7.02	1.05	0.98	0.66	1.67	1.25
S.E.± for cv	0.95	0.76	4.96	0.74	0.69	0.47	1.18	0.88

I= first season (2002/2003); Π= second season (2003/2004)

Means in the same column are not significantly different at P = 0.05, according to the Duncan's Multiple Range Test.

The percentage of the capsules on the main stem decreased significantly with nitrogen application in both seasons, and all nitrogen levels showed similar and significantly lower capsule percentages than the control. In contrast, the percentage of capsules on the branches increased with nitrogen application in both seasons; all nitrogen levels produced similar and significantly higher capsule percentages than the control. Phosphorus significantly reduced the percentage of capsules on the main stem in the second season. All phosphorus levels produced similar and significantly lower capsule percentages than the control. However, phosphorus significantly increased the percentage of capsules on the branches in the second season; all phosphorus levels produced similar and significantly higher capsule percentages than the control. Khidir showed higher capsule percentage on the main stem than Promo in both seasons, but the difference was significant in the first season only. On the other hand, Promo showed higher capsule percentage on the branches than Khidir in both seasons, but the difference was significant in the first season only (Table 2).

Nitrogen resulted in a significant increase in seed yield in both seasons. In the first season, the highest yield was achieved at the highest nitrogen level (120 kgN/ha), whereas the lower two levels showed similar but significantly higher yields than the control. In the second season, all nitrogen levels resulted in similar but significantly higher yields than the control. All phosphorus levels showed similar and significantly higher yields than the control in the second season. There were no significant differences between cultivars in yield, but Promo gave higher yield than Khidir in both seasons (Table 2).

There was significant interaction between cultivars and nitrogen on yield in both seasons; Khidir gave its highest yield at the highest nitrogen level (120 kgN/ha), but Promo gave its highest yield with no nitrogen (Table 3).

Table 2. Effects of nitrogen and phosphorus on percentage of capsules on the main stem and branches and seed yield

Treatment	Capsules on main stem(%)		Capsules on branches (%)		Seed yield (kg/ha)	
	I	II	I	II	I	II
N (kgN/ha						
0	89.9a	7.5a	10.0b	22.5b	432.0c	501.0b
40	83.3a	9.3b	16.7a	30.7a	549.0b	795.0a
80	76.9b	8.6b	23.1a	31.4a	539.0b	845.0a
120	76.5b	9.1b	23.5a	30.9a	635.0a	733.0a
P(kgP_2O_5/ha)						
0	82.6a	7.4a	17.4a	22.6b	522.0a	651.0b
40	80.8a	9.1b	19.2a	30.9a	540.0a	732.0a
80	82.7a	0.3b	17.3a	29.7a	523.0a	778.0a
120	80.5a	7.7b	19.5a	32.3a	570.0a	712.0a
Cultivars						
Khidir	84.5a	1.9a	15.5a	28.0a	525.0a	693.0a
Promo	78.8b	0.3a	21.2b	29.7a	552.0a	744.0a
S.E $\pm$ for N	3.67	1.33	3.66.	1.33	30.0	47.3
S.E $\pm$ for P	1.28	1.31	1.23	1.31	30.0	27.4
S.E $\pm$ for cv	0.90	0.93	0.90	0.93	21.2	19.4

I = first season (2002/2003); II = second season (2003/2004)

Means in the same column followed by the same letter are not significantly different at P = 0.05, according to the Duncan's Multiple Range Test.

Table 3. Effect of cultivar and nitrogen interaction on sesame yield (kg/ha)

Nitrogen treatment (kg/ha)	2002/2003		2003/2004	
	Khidir	Promo	Khidir	Promo
0	429.0d	526.0bcd	479.0e	899.0a
40	436.0d	552.0ab	523.0e	791.0b
80	519.0d	626.0ab	655.0d	740.0bc
120	579.0a	643.0a	635.0d	727.0bcd
S.E.±	42.4		38.8	

Means followed by the same letter (s) are not significantly different at P = 0.05, according to Duncan's Multiple Range Test.

DISCUSSION

The positive effect of nitrogen on the vegetative growth of sesame reported in this study corroborated the findings of a number of workers (e.g., Vyas et *al.* 1999; Patra 2001). Ahmed (1987) found no response by sesame to nitrogen in the sandy soils of Kordufan; this could be attributed to the low rainfall at that area and the low moisture holding capacity of the sandy soil. Thus, the positive response to nitrogen in this study could be due to the more favourable rainfall, and to the clay soils which possibly reduced nitrogen losses by leaching and/or volatilization.

The effect of phosphorus on vegetative growth was evident in the second season only. The lack of response in the first season possibly resulted from low phosphorus availability in the alkaline heavy clay soils at the site. The significant response to phosphorus in the second season could be attributed to increased solubility, due to the higher rainfall in that season, in addition to phosphorus residues carried over from the first season. Similar effects of phosphorus on sesame were reported by Beherra *et al.* (1994) and Prakash and Tandon (2004). Ahmed (1987), however, found no response to phosphorus in the sandy soils of Kordufan, possibly due to the same reasons mentioned earlier for the lack of response to nitrogen in that area.

Both nitrogen and phosphorus significantly increased height to the first capsule, which could be due to the effects of these nutrients on plant height mentioned earlier. This effect has practical implications since height to the first capsule affects maturity and harvesting. Similar finding was reported by Abdel Rahman *et al*. (2003).

Nitrogen and phosphorus significantly increased the number of capsules per plant and seed yield. Such effects on yield could be due mainly to general improvement of growth and increase of capsule number by these nutrients. El Mahadi and Ahmed (2009) reported positive effects of nitrogen on growth, yield and yield components of irrigated sesame in he Nile State, northern Sudan. Subrahamanyan and Arulmozhi (1999) reported similar findings in India. A number of studies also showed positive effects of phosphorus on sesame yield (Chaplot *et al.* 1991; Beherra *et al.* 1994; Prakash and Tandon 2004; Qayum *et al*. 2005). The higher yield in the second season could be due to the higher rainfall in that season.

The percentage of capsules on the main stem decreased, while that on the branches increased, with nitrogen and phosphorus application. This could be due to a shift in assimilate partitioning in favour of capsules on the branches. Branching is not desirable in sesame, because it may delay maturity and harvest and increase the risk of capsule shattering and seed loss.

The results of this study confirm previous findings that sesame can respond to fertilizers under favourable moisture conditions, and that different varieties may differ in their response to fertilizers as indicated by the interaction between cultivars and nitrogen.

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إستجابة صنفين من السمسم للتسميد بالنيتروجين والفوسفور تحت ظروف الأمطار*

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موجز البحث: أجريت تجربة حقلية لموسمين متتالين (2003/2002 و20042003) في المزرعة التجريبية لكلية الزراعة بجامعة سنار بأبو نعامة و ذلك بهدف دراسة إستجابة صنفين من السمسم للتسميد بالنيتروجين والفوسفور تحت ظروف الأمطار. أستخدمت أربعة مستويات من النيتروجين (0، 40، 80 ،120كجم للهكتار) وأربعة مستويات من الفوسفور (0، 50، 100، 150 كجم للهكتار). أستخدم الصنفان خضر وبرومو في التجربة وسماد اليوريا (46% نيتروجين) مصدرًا للنيتروجين وسماد السيوبر فوسفات الثلاثي (48% فوسفور) مصدرًا للفوسفور. نفذت التجربة بتصميم القطع المنشقة- المنشقة بأربعة مكررات. تم وضع معاملات النيتروجين في القطع الرئيسية ومعاملات الفوسفور والأصناف في القطع المنشقة و المنشقة – المنشقة، علي التوالي. أوضحت النتائج تأثيرًا معنويًا للنيتروجين والفوسفور علي طول النبات، والوزن الجاف للمجموع الخضري، و إرتفاع الثمرة الأولي، وعدد الثمار في النبات، ونسبة الثمار في الساق الرئيسية و في الفروع، والإنتاجية من البذور. كانت هنالك فروقات معنوية بين الصنفين في النمو والإنتاجية حيث كان الصنف برومو أفضل من الصنف خضر. كذالك كان هنالك تأثير معنوي للتفاعل بين الأصناف والنيتروجين علي الإنتاجية في الموسم الثاني.

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