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Interactive Effect of Plant Density and Nitrogen Level on Growth and Yield of Sesame under Irrigation in Northern Sudan

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Abstract: The interactive effect of plant density and nitrogen fertilizer levels on growth and yield of sesame (*Sesamum indicum* L. cv. Shuak) was investigated under irrigation. The field experiments were conducted during 2005/06 and 2006/07 seasons in the Experimental Farm of the Faculty of Agriculture at Darmali, Nile Valley University, River Nile State, Sudan. Four plant densities (100 000, 150 000, 200 000 and 250 000 plants/ha) and three levels of nitrogen fertilizer (0, 22 and 44 kg N/ha) were used. A split-plot design with four replications was used to execute the experiment. The plants were sown during the first week of July. The results showed that plant height, number of branches per plant, height to first capsule and leaf area index were significantly affected by plant density and level of nitrogen fertilizer. The highest values of these characters were obtained with a plant density of 250 000 plants/ha and treatment receiving 44 kg N/ha. Increasing plant density significantly decreased the number of capsules per plant, seed yield per plant and increased seed yield per unit area. Nitrogen levels significantly increased seed yield and number of capsules per plant. Significant interaction was noted, and the highest seed yield was obtained by the application of 44 kg N/ha at a planting density of 150 000 plants/ha.

Key words: Sesame; plant population; nitrogen fertilizer

INTRODUCTION

Sesame (*Sesamum indicum* L.) is the most important vegetable oil crop in Sudan, ranking third in area after sorghum and millet. It is a food crop, raw material for industry, feed for livestock, and leading export crop. However, the yield is highly variable depending upon the amount and distribution of rainfall, cultural practices and cultivars (Abdalla and Abdel Nour 2001; Khidir 2007). Therefore, under these circumstances,

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maintaining an optimum plant density plays a vital role in realizing the yield potential of the crop (Guanamurthy *et al*. 1992; Ghosh and Patra, 1994; Caliskan *et al*. 2004). Generally, a favourable increase in yield is obtained with increase in plant population, and a stand of up to 222 000 plants/ha is considered necessary to obtain reasonably good seed yield (Subrahmaniyan and Arulmozhi 1998; Adebisi *et al*. 2005). With further increase in density beyond 330 000 plants/ha, the number of capsules per plant and seed weight per capsule decreased significantly (Mujaya and Yerokum 2003). Recently, however, Imoloame *et al*. (2007) concluded that a seed rate of 6 kg/ha produced the highest yield.

The positive effect of fertilizer application, mainly nitrogen, on sesame yield was previously shown by many researchers. Ashfaq *et al.* (2001) found that seed yield and yield components increased with increasing nitrogen rate, and the highest yield was obtained with 20 kg/ha nitrogen. Also, Sinharoy *et al*. (1990) concluded that the application of 30 and 60 kg N/ha gave average yields of 651 and 801 kg/ha, respectively, compared with 358 kg/ha without nitrogen application. However, the optimum level of fertilizer application must be related to plant population especially on poor soils. The interactive effect of planting densities and nitrogen levels on sesame performance has not been fully studied. The objective of this investigation was to study the effect of plant density and level of nitrogen fertilizer on growth and yield of sesame under irrigation.

MATERIALS AND METHODS

An experiment was carried out, during 2005/06 and 2006/07 growing seasons, at the Faculty of Agriculture Farm, Nile Valley University, Darmali, River Nile State, Sudan (latitude $17^{o}48'$ N; longitude $34^{o}00'$E and altitude 346.5 m *asl*). The soil of the experimental plots was classified as calcareous matrix strongly alkaline with low permeability to water and low in nitrogen and humus content. The treatments were arranged in split-plot design with four replications. Four plant populations (i.e., 1.0×10^5, 1.5×10^5, 2.0×10^5 and 2.5×10^5 plants/ha) were assigned to the main-plots and three levels of nitrogen fertilizer (0, 22 and 44 kg N/ha) to the subplots.

The experimental site was disc ploughed, disc harrowed, leveled and ridged at 70 cm apart. The plot size was 3.5×7 m consisting of five ridges 7 m in length. Sesame (*Sesamum indicum* cv. Shuak) was sown on the first week of July in both seasons. The crop was irrigated every 7 days, and the plants were thinned to achieve the required plant densities. Nitrogen fertilizer, in the form of urea, was applied in two equal doses after the third and fourth week after sowing.

Data were collected on some growth attributes (leaf area index, plant height, number of branches per plant and height to first capsule) and yield components (number of capsules per plant, 1000-seed weight and seed yield). Statistical analysis was carried out using MSTAT-C computer programme.

RESULTS AND DISCUSSION

Plant height, number of branches per plant and height to first capsule were significantly affected by plant density and nitrogen fertilizer (Table 1). In this regard, the tallest plants were obtained with a plant density of 250 000 plants/ha and 44 kg N/ha. A similar trend was observed with respect to the height of the first capsule. Similar findings were reported earlier by Guanamurthy *et al*. (1992), Ghosh and Patra (1994) and Caliskan *et al.* (2004). On the other hand, the highest number of branches (2.9) was produced under low plant density (100 000 plants/ha) (Table 1). However, increasing the level of nitrogen fertilizer increased the number of branches/plant. A similar observation was reported by Sinharoy *et al.* (1990) who showed that the number of branches per plant is highly responsive to nitrogen fertilizer. This may be attributed to relatively less inter plant competition for space, light, nutrients, moisture, etc. Similar results were also reported by Majumdar and Roy (1992) and Kafiriti and Deckers (2001).

Table 1. Effect of plant population and nitrogen level on plant height, number of branches/plant and height to first capsule during 2005/06 season

Treatment	Plant height (cm)	Branches/plant (No.)	Height of 1st capsule (cm)
Plant population (000)/ha			
100	85.2	2.9	56.2
150	91.6	2.4	56.7
200	91.6	2.0	58.2
250	95.6	2.0	61.4
$LSD_{0.05}$ (density)	3.5	0.1	2.3
Nitrogen level (kg N/ha)			
0	69.6	1.9	40.4
22	72.2	2.1	40.6
44	77.8	2.7	43.0
$LSD_{0.05}$ (nitrogen)	2.7	0.1	1.7
$LSD_{0.05}$ (interaction)	NS	NS	NS

Figure 1 shows the effect of plant population, nitrogen fertilizer and their interaction on leaf area index during the ontogeny of sesame plants. In all treatments, leaf area index increased steadily till two months after sowing and declined thereafter due to leaf senescence. The maximum leaf area index was attained at high planting density and high level of nitrogen fertilization. The same results were reported by Subrahmaniyan and Arulmozhi (1998).

Plant density, nitrogen level and their interaction had a significant ($p \leq 0.05$) effects on number of capsules per plant in both seasons (Table 2). Increasing plant population to 250 000 plants/ha resulted in substantial reduction in the number of capsules/plant. This may be attributed to the competition between the different plant parts under high planting density. Similar findings were reported by Mujaya and Yerokum (2003), Adebisi *et al.* (2005) and Abdalla *et al.* (2008). However, the number of capsules per plant increased with increasing nitrogen levels in both seasons (Table 2). These results confirm the findings of Ashfaq *et al.* (2001). On the

other hand, plant population had no significant effect on 1000-seed weight (Table 2). Similar results were reported by Mujaya and Yerokum (2003). Also, the 1000-seed weight is insignificantly affected by nitrogen application as reported by Sinharoy *et al*. (1990).

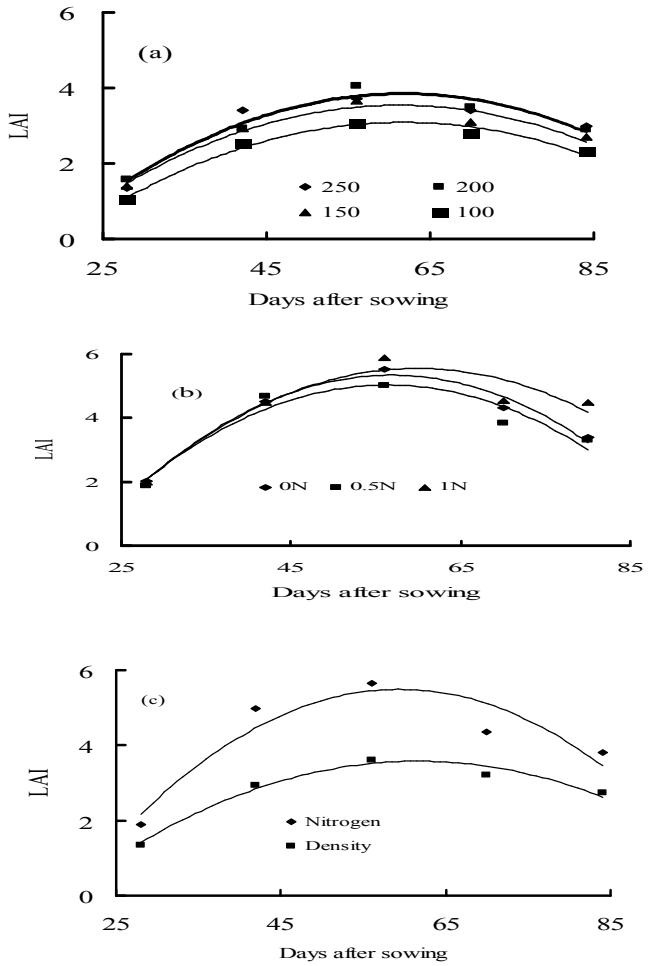

Fig.1. Leaf area index as affected by (a) plant densities (100, 150, 200 and 250 thousands plants/ha), (b) nitrogen levels (0, 22 and 44 kg N/ha) and (c) interaction during 2005/06 season

Table 2. Effect of plant population and nitrogen on number of capsules per plant and 1000-seed weight of sesame during 2005/06 and 2006/07 seasons

Nitrogen level (kg N/ha)	Plant population (000) /ha				
	100	150	200	250	Mean
	No. of capsules/plant,2005/06 season				
0	25.6	23.3	17.7	15.5	20.5
22	30.7	25.5	23.7	18.0	24.5
44	28.9	24.4	26.6	25.1	26.3
Mean	28.4	24.4	22.7	19.5	
$LSD_{0.05}$ (density) 1.11; $LSD_{0.05}$ (nitrogen) 1.29; $LSD_{0.05}$ (interaction) 0.93					
	No. of capsules/plant, 2006/07 season				
0	27.2	21.9	18.4	24.0	22.9
22	26.0	24.4	25.6	19.3	23.8
44	37.1	24.5	28.9	22.5	28.3
Mean	30.1	23.6	24.3	21.9	
$LSD_{0.05}$ (density) 2.22; $LSD_{0.05}$ (nitrogen) 2.29; $LSD_{0.05}$ (interaction) 3.84					
	1000-seed weight, 2005/06 season				
0	2.6	2.4	2.6	2.7	2.6
22	2.6	2.7	2.6	2.8	2.7
44	2.6	2.6	2.7	2.7	2.7
Mean	2.6	2.6	2.6	2.7	
$LSD_{0.05}$ (density) NS; $LSD_{0.05}$ (nitrogen) NS; $LSD_{0.05}$ (interaction) 0.2					
	1000-seed weight, 2006/07 season				
0	2.8	2.6	2.8	2.7	2.7
22	2.8	2.7	2.7	2.7	2.8
44	2.7	2.7	2.7	2.6	2.7
Mean	2.7	2.7	2.7	2.7	
$LSD_{0.05}$ (density) NS; $LSD_{0.05}$ (nitrogen) NS; $LSD_{0.05}$ (interaction) 0.2					

Generally, increasing the number of plants per unit area increases the competition among plants for soil moisture, nutrients, light and carbon dioxide. This might explain the highly significant effects of plant density on seed yield per plant and seed yield per unit area obtained in this study. For example, increasing plant density significantly decreased seed yield per plant, in both seasons (Table 3). This was primarily due to the reduction in the number of capsules per plant at high plant population. Similarly, Levy *et al*. (1985) and Abdalla *et al.* (2008) pointed out that seed yield per plant decreased substantially with increasing plant density. They attributed this reduction to low pod yield and to interplant competition for assimilates. In contrast, seed yield per unit area was significantly increased by increasing planting density, in both seasons. Plant population in the range of 150 000 – 200 000 plants/ha produced the highest seed yield in both seasons (Table 3). Similar results were reported by other researchers (Lazim 1973; Abdalla *et al.* 2008).

High dose of nitrogen fertilizer enhanced the vegetative growth and development of yield attributes as indicated by greater number of branches and capsules per plant. This might explain the consistent increases in seed yield with increase in nitrogen level. These findings are in accord with those of Balasubramaniyan *et al.* (1995). Significant interactions between nitrogen levels and plant population densities on seed yield were noted, and the highest values were obtained by application of 44 kg N/ha at planting density of 150 000 plants/ha. This suggests that nitrogen level seemed to be the limiting growth factor particularly at high planting densities. These results agree with those reported by other researchers (Ghosh and Patra 1994; Mujaya and Yerokum 2003; Abdalla *et al.* 2008).

In conclusion, irrigated sesame can be grown at high planting density ($>1.5\times10^5$ plants/ha) provided that nitrogen fertilizer, at a rate of 44 kg N/ha, is applied to the soil.

Table 3. Effect of plant population and nitrogen level on sesame seed yield per plant (g) and seed yield (kg/ha) during 2005/06 and 2006/07 seasons

Nitrogen level (kg N/ha)	Plant population (000) /ha				
	100	150	200	250	Mean
	Seed yield (g/plant), 2005/06 season				
0	2.2	2.3	2.1	1.6	2.0
22	2.0	1.6	1.5	1.1	1.6
44	2.3	2.4	2.4	2.0	2.3
Mean	2.2	2.1	2.0	1.6	
$LSD_{0.05}$ (density) 0.1; $LSD_{0.05}$ (nitrogen) 0.3; $LSD_{0.05}$ (interaction) 0.2					
	Seed yield (g/plant), 2006/07 season				
0	1.6	1.5	1.4	0.9	1.4
22	2.2	1.4	1.7	1.2	1.6
44	2.7	1.8	1.8	1.2	1.9
Mean	2.2	1.6	1.6	1.1	
$LSD_{0.05}$ (density) 0.1; $LSD_{0.05}$ (nitrogen) 0.1; $LSD_{0.05}$ (interaction) 0.2					
	Seed yield (kg/ha), 2005/06 season				
0	683	675	704	643	676
22	585	692	825	799	725
44	703	823	694	902	781
Mean	657	730	741	781	
$LSD_{0.05}$ (density) 55.5; $LSD_{0.05}$ (nitrogen) 44.; $LSD_{0.05}$ (interaction) 96.2					
	Seed yield (kg/ha), 2006/07 season				
0	799	932	984	879	896
22	927	1004	930	967	957
44	946	1129	1002	992	1017
Mean	891	1022	972	946	
$LSD_{0.05}$ (density) 40.9; $LSD_{0.05}$ (nitrogen) 52.4; $LSD_{0.05}$ (interaction) 70.8					

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تأثير التداخل بين الكثافة النباتية ومستوى سماد النيتروجين على نمو وإنتاجية السمسم تحت الري في شمال السودان

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موجز البحث: أجريت دراسة لتأثير التداخل بين الكثافة النباتية ومستوى سماد النيتروجين على نمو وإنتاجية السمسم – (الصنف الشوك) تحت الري. نفذت التجارب الحقلية خلال موسمي 06/2005 و 07/2006 بالمزرعة التجريبية لكلية الزراعة بدارمالي - جامعة وادي النيل، ولاية نهر النيل. وباتباع نظام القطع المنشقة بأربعة مكررات. زرعت النباتات بمعدل 000 100 و 000 150 و 000 200 و 000 250 نبات للهكتار واستخدمت ثلاثة مستويات من سماد النيتروجين (0 و22 و 44 كجم نيتروجين للهكتار). أظهرت النتائج أن طول النبات وعدد الأفرع في النبات والإرتفاع للعليبة الأولى ومعامل مساحة الورقة تأثرت معنوياً بالكثافة النباتية ومستوى النيتروجين، وكانت أعلى قيمة لتلك المؤشرات في المعاملات ذات الكثافة النباتية العالية (000 250 نبات للهكتار) والمستوى العالي من سماد النيتروجين (44 كجم نيتروجين/هكتار). أدت زيادة الكثافة النباتية إلى نقص معنوي في عدد العليبات في النبات وإنتاجية البذور في النبات بينما زادت من إنتاجية النبات في وحدة المساحة، كما أن مستويات النيتروجين زادت معنويا من إنتاج البذور وعدد العليبات في النبات. وكان تأثير التداخل معنوياً، وأعلى إنتاجية تم الحصول عليها عند إضافة 44 كجم نيتروجين للهكتار واستخدام كثافة نباتية حوالي 000 150 نبات/هكتار.

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