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Response of Seed Yield, Yield Components and Oil Content to the Sesame Cultivar and Nitrogen Fertilizer Rate Diversity

Fathy S. El-Nakhlawy and **Mohamed A. Shaheen**

Department of Arid Land Agriculture,
Faculty of Meteorology, Environment and Arid Land Agriculture
King Abdulaziz University, Jeddah, Saudi Arabia

Abstract. This study was conducted at the Agricultural Research Station, King Abdulaziz University at Hada El-Sham during 2007 and 2008 seasons to improve the seed yield of sesame (*Sesamum indicum* L.) in the Makkah Region, Saudi Arabia. Split plot design with four replications was used in this study. Main plot treatments were four nitrogen rates (0, 100, 150 and 200 kg N/ha) and the sub plot treatments were three diverse sesame cultivars, Saudi Local *cv.*, Egyptian *cv.* "Shandaweel" and Sudanese *cv.* "Sudan-1". The obtained results of the combined analysis of the two seasons showed significant interaction effects on the flowering date, plant height, No. of branches/plant, No. of fruits/plant, seed weight/plant and seed yield/ha, while no significant effects were found for the N fertilizer rate × cultivar interaction, nitrogen fertilizer or sesame cultivars on seed oil content.

Saudi Local *cv.* under the 150 and 200 kg N/ha produced the highest significant seed yield/ha comparing with the other treatments. Seed yields/ha were 862.47 and 869.45 kg/ha for Saudi Local *cv.* under the 150 and 200 kg N/ha, respectively. Shandaweel *cv.* occupied the 2nd rank concerning seed yield/ha with 733.37 and 729.89 kg/ha under 150 kg N/ha and 200 kg N/ha, respectively. Sudan-1 *cv.* produced the lowest seed yield under the different nitrogen fertilizer rates. Oil contents of the three cultivars were 45.37, 45.96 and 45.80%, for Saudi Local *cv.*, Shandaweel *cv.* and Sudan-1 *cv.*, respectively.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest oil seed crops. Sesame seeds have a high nutritive value and are used in baking products and oil extraction. Sesame is considered as a drought tolerant crop (Jefferson, 2003). Langham and Wiemers (2006) stated that sesame crop is the queen of vegetable oils. Its oil has high degrees of stability and resistance to rancidity.

Sesame area in Saudi Arabia is around 2920 ha and Makkah region only planted 182 ha (Agric. Stat. Year Book, 2006). Few published papers are available on sesame crop. Among them, Reddy and Narayanan (1987) reported that around 80% of the dry weight is produced during the fruit and seed formation in plants. Dorothea (1986) found significant differences among sesame varieties collected from 20 countries. Effects of nitrogen, phosphorus and potassium fertilizer rates were studied by Lee, *et al.* (1986) and the best fertilizer rates were found to be 80: 60: 80 kg/ha for N, P_2O_5 and K_2O, respectively. Tiangtrong and Thurling (1986) indicated that Hnan Dan variety was the earliest and highest in seed yield compared with the other studied varieties. Oplinger, *et al.* (1990) showed that the optimum nitrogen fertilizer rate for sesame was 90-120 kg N/ha in the < 2% organic matter soil. Benett and Wood (1995) reported that fertilizer rates depend on soil fertility, soil type and the previous crop.

In India, Nath, *et al.* (2003) indicated that sesame growth rate was negatively affected by low temperature and low effective photosynthesis rate. Rama variety significantly dominated over B-57 variety in seed yield. Temperature and variety affected seed yield variation by 69 and 39%, respectively. Seed yield of sesame significantly differed from season to another during 1998-2000 as found by Sharma (2005). This investigation aims to study the effects of four nitrogen fertilizer rates on the seed yield, yield components and oil content in three diverse sesame cultivars under west region of Saudi Arabia conditions.

Materials and Methods

This investigation was conducted at the Agricultural Experiment Station, King Abdulaziz University, Saudi Arabia during 2007 and 2008 seasons to study the effects of four nitrogen fertilizer rates on the seed yield, yield components and oil content in three diverse sesame cultivars.

This study was carried out in a split plot design with four replicates, according to Quinn and Keough (2002). The main plot treatments were nitrogen fertilizer rates, 0.0, 100, 150 and 200 kg N/ha added in 4 equal parts starting after 20 days after planting, and the rest three parts were added with 10 days time intervals. Sub plots were occupied by three diverse sesame cultivars, the local Saudi cultivar, Egyptian cultivar Shandaweel and Sudan cultivar Sudan-1. Sub plot size was 3m long and 2.5m apart with 50cm between the rows, and 25cm between the hills, with 2 plants in each hill. Spraying irrigation system was used in this study.

The two season experiments were sawn at January, 10 and January, 21 during 2007 and 2008 seasons, respectively. Local culture practices were used during the time of experiments except the studied treatments. Experimental soil analysis in two depths according to Day (1956) and Jackson (1973) revealed 88.12 & 81.65% for sand, 0.573 & 0.61% for organic matter and 0.78 & 0.68 dSm^{-1} for soil Ec unit for the (0-30 cm) and (30-60 cm) soil depths, respectively. Irrigation water chemical analysis revealed 29.79, 3.06, 0.04, 8.73 and 11.06 mlequivalent/L for Na^{+}, Ca^{++}, K^{+} and SO_4^{++}, respectively and the irrigation water Ec was 1.79 dSm^{-1} at 7.6 pH.

Twenty random guarded plants were chosen from each subplot to determine flowering date (day), plant height (cm), no. of branches/plant, no. of fruits/plant and seed weigh/plant (g), while seed yield/ha was converted from the seed yield of (2.5×2) m^2 area from each subplot. Two random seed samples were chosen from each subplot to determine oil content using Soxhlet apparatus and n-hexane (60ºC) as an extraction solvent according to A.O.A.C. (1980). Combined statistical analysis over the two seasons for the studied data was done after applying the analysis of variance assumptions, and means were statistically analyzed using LSD at $p \leq 0.05$ according to Quinn and Keough (2002) using SAS (2000).

Results and Discussion

According to the statistical combined analysis over the two seasons, the interaction between nitrogen fertilizer rate (N) and sesame cultivar (*cv.*) was significant ($p \leq 0.05$) for flowering date, plant height, no. of branches/plant, no. of fruit/plant, seed weight/plant and seed yield/ha. Means of these traits will be discussed under the effect of nitrogen

fertilizer rate × cultivar interaction. Oil content will be discussed under the main effects of nitrogen fertilizer and cultivars only because the N × Cv was insignificant for oil content.

Results of mean comparisons of flowering date under the effects of nitrogen fertilizer × cultivar as average of the two seasons, revealed that Saudi local *cv.* was the latest *cv.* in flowering date, especially under the high fertilizer rates. The longest time to flowering was 75.5 days for the local Saudi cultivar under 200 kg N/ha, and equal with the same cultivar under 150 kg N/ha, and Sudan-1 *cv.* under 200 kg N/ha. Shandaweel *cv.* was the earliest cultivar in flowering under all nitrogen rates. Days to flowering for Shandweel *cv.* were 47, 52.5, 57 and 60 days under 100, 150 and 200 kg N/ha rates, respectively (Table 1).

The differences between flowering dates of Sesame cultivars under the nitrogen fertilizer rates might be due to the effects of cultivar genetic background and nitrogen fertilizer rates interaction, and/or to the genetic × environment interaction to which plants are subjected in Makkah region including photoperiod and temperature during the sesame plant growth period up to flowering.

Table 1. Means of flowering date (day), plant height (cm), no. of branches/plant and no. of fruits/plant under the effect of the interaction between nitrogen fertilizer rate and sesame cultivar as an average of 2007 and 2008 seasons.

Nitrogen fertilizer rate (kg N/ha)	Cultivar	Flowering date (day)	Plant height (cm)	No. of branches/plant	No. of fruits/plant
0	Local Saudi	53.5	74.34	4.93	32.35
	Shandweel	47.0	61.76	3.91	25.39
	Sudan-1	50.0	62.38	3.10	16.67
100	Local Saudi	62.5	84.03	6.44	49.77
	Shandweel	52.5	69.80	4.94	36.70
	Sudan-1	56.5	72.36	4.88	28.83
150	Local Saudi	69.5	91.29	8.11	69.26
	Shandweel	57.0	75.05	6.30	48.03
	Sudan-1	61.0	77.12	5.92	37.12
200	Local Saudi	75.5	96.98	8.67	71.16
	Shandweel	60.0	80.75	6.98	55.49
	Sudan-1	65.5	78.83	5.49	42.54
LSD (≤ 0.05):					
N_iV_i-N_iV_j		9.02	13.03	0.85	8.44
N_iV_i-N_jV_j		10.64	15.21	1.29	9.48
N_iV_i-N_jV_i		10.64	15.21	1.29	9.48

Mean comparisons of plant height under the interaction between nitrogen fertilizer rates and cultivars (Table 1) show that local Saudi *cv.* plant height did not significantly differ under the 100, 150 and 200kg N/ha. Plant heights were 96.98, 91.29 and 84.03cm, under 200, 150 and 100kg N/ha, respectively. Shandweel *cv.* plants had heights of 80.75 and 75.05cm under the 200 and 150kg N/ha, respectively, while the shortest plants were produced under 0.0kg N/ha for the three studied cultivars.

Concerning the number of branches/plant, data in Table 1 show that the highest no. of branches/plant was produced from local Saudi cultivar under 200, 150kg N/ha with 8.67 and 8.11 branches/plant for the two previous nitrogen rates, respectively. Shandweel *cv.* followed the local Saudi *cv.* with significant difference, under the 200 and 150kg N/ha with 6.98 and 6.30 branches/plant, respectively, but no significant difference was detected between local Saudi *cv.* and Shandweel *cv.* under the 100kg N/ha. Sudan-1 *cv.* produced the lowest branches/plant under any nitrogen fertilizer rates. As for the number of fruits/plant, means in Table 1 illustrate that the local Saudi *cv.* produced the highest no. of fruits/plant under 200kg N/ha, 150kg N/ha with means of 71.16 and 69.26 fruits/ha under the previous nitrogen fertilizer rates, respectively. Shandweel *cv.* under the 200kg N/ha significantly decreased from the local Saudi *cv.* producing 55.49 fruits/plant, but without significant difference from the local Saudi cv. under 100kg N/ha which produced 49.77 fruits/plant. Sudan-1 *cv.* was the significantly lowest in no. of fruits/plant under all nitrogen fertilizer rates.

Data presented in Table 2 show that the local Saudi *cv.* produced the highest seed weight/plant under 150kg N/ha (16.13 g/plant) followed by the same cultivar under 200kg N/ha (12.09 kg/ha), then Shandweel *cv.* under 200 or 150kg N/ha without significant differences from local Saudi *cv.* under 100kg N /ha. Sudan-1 *cv.* produced the lowest seed weight/plant under any nitrogen fertilizer rates.

Performance of seed yield components, *i.e.*, seed weight/plant, no. of branches and fruits/plant reflected on the behavior of seed yield/ha under the cultivar × nitrogen fertilizer rate interaction. Means of seed yield/ha (Table 2) indicate that the local Saudi *cv.* under 150 and 200kg N/ha

significantly dominated over the previous cultivar × nitrogen fertilizer treatments. Seed yield/ha were 862.47 and 869.45 kg/ha for the local Saudi *cv.* under the two previous nitrogen rates, respectively. Shandweel *cv.* under 150 and 200 kg N/ha produced 733.37 and 729.89 kg/ha, respectively without significant differences from the local Saudi *cv.* under 100kg N/ha, but Sudan-1 *cv.* occupied the last category in seed yield/ha under different nitrogen fertilizer rates, where the highest seed yield was 600.35 kg/ha under the 200 kg N/ha.

Table 2. Means of seed weight/plant (g), seed yield/ha (kg), oil content (%) under the effect of the interaction between nitrogen fertilizer rate and Sesame cultivar as an average of 2007 and 2008 seasons.

Nitrogen fertilizer rate (kg N/ha)	Cultivar	Seed weight/plant (g)	Seed yield/ha (kg)	Oil content (%)
0	Local Saudi	6.67	515.95	44.93
	Shandweel	5.26	381.47	45.69
	Sudan-1	4.34	259.44	45.23
100	Local Saudi	9.32	725.46	45.62
	Shandweel	7.97	608.47	45.84
	Sudan-1	6.09	427.50	45.86
150	Local Saudi	16.13	862.47	45.56
	Shandweel	9.42	733.37	46.24
	Sudan-1	8.11	586.82	46.27
200	Local Saudi	12.09	869.45	45.37
	Shandweel	9.98	729.89	45.77
	Sudan-1	8.67	600.35	45.83
LSD (≤ 0.05):				
N_iV_i-N_iV_j		1.37	121.34	NS
N_iV_i-N_jV_j		2.04	128.16	NS
N_iV_i-N_jV_i		2.04	128.16	NS

NS: Not significant at ≤ 0.05 according to LSD test.

The obtained results might be discussed as effects of the cultivar genotype × environment interaction during the two studied seasons. These findings are similar to the results obtained by Dorothea (1986) and Tiangtrong and Thurling (1986), which revealed that sesame varieties were significantly different in seed yield and yield components under the different nitrogen fertilizer requirements and environmental conditions. Also, Oplinger, *et al.* (1990) stated that sesame varieties significantly

differ in seed yield, plant characteristics, and oil content as their fertilizer requirements and genotype differ. Nath, *et al.*, (2003) indicated that sesame varieties were significantly different in seed yield as temperature variation during the growth period and concluded that the temperature variation contributed with 39% in seed yield variation.

Oil content (%) of the sesame seeds did not significantly differ ($p \leq 0.05$) under the different nitrogen fertilizer rates. Oil contents ranged from 45.28% under 0.0kg N/ha to 46.03% under 150kg N/ha (Table 3). Also, no significant differences were detected between the studied cultivars in oil contents. Oil content means were 45.37%, 45.96%, and 45.80% for the local Saudi *cv.*, Shandweel *cv.* and Sudan-1 *cv.*, respectively (Table 4).

Table 3. Means of seed weight/plant (g), seed yield/ha (kg) and oil content (%) under the effects of four nitrogen fertilizer rates as an average of the 2007 and 2008 seasons.

Nitrogen fertilizer rate (kg N/ha)	Seed weight/plant (g)	Seed yield/ha (kg)	Oil content (%)
0	5.42c*	385.62c	45.28a
100	7.79b	590.48b	45.78a
150	9.74a	727.56a	46.03a
200	8.41a	733.09a	45.66a

*Means followed by the same letter are not significantly different according to LSD at ≤ 0.05 level of probability.

Table 4. Means of seed weight/plant (g), seed yield/ha (kg) and oil content (%) of the three Sesame cultivars as an average of the 2007 and 2008 seasons.

Cultivar	Seed weight/plant (g)	Seed yield/ha (kg)	Oil content (%)
Local Saudi	9.94a*	745.83a	45.37a
Shandweel	8.16b	613.20b	45.96a
Sudan-1	6.80c	468.53c	45.80a

*Means followed by the same letter are not significantly different according to LSD at ≤ 0.05 level of probability.

Means of flowering date, plant height, no. of branches/plant and no. of fruits/plant under the four nitrogen rates are presented in Table 5 and means of the three studied cultivars for the previous characteristics are presented in Table 6. The paper discussed these traits under the interaction between cultivar × nitrogen fertilizer rates.

Table 5. Means of flowering date (day), plant height (cm), no. of branches/plant and no. of fruits/plant under the effect of nitrogen fertilizer rates as an average of 2007 and 2008 seasons.

Nitrogen fertilizer rate (kg N/ha)	Flowering date (day)	Plant height (cm)	No. of branches/plant	No. of fruits/plant
0	50.17c*	66.26c	3.98c	24.72c
100	57.17b	75.40b	5.42b	38.15b
150	62.84b	81.15a	6.78a	51.35a
200	67.00a	85.52a	7.05a	56.33a

*Means followed by the same letter are not significantly different according to LSD at ≤ 0.05 level of probability.

Table 6. Means of flowering date (day), plant height (cm), no. of branches/plant and no. of fruits/plant of the three Sesame cultivars as an average of 2007 and 2008 seasons.

Cultivar	Flowering date (day)	Plant height (cm)	No. of branches/plant	No. of fruits/plant
Local Saudi	65.25a*	86.66a	6.69a	55.48a
Shandweel	54.13b	71.84b	5.53b	41.30b
Sudan-1	58.25b	72.67b	4.45c	31.13c

*Means followed by the same letter are not significantly different according to LSD at ≤ 0.05 level of probability.

Finally, this study showed that the local Saudi *cv.* under 150kg N/ha produced the highest seed yield/ha and oil content, followed by Shandweel *cv.* under 150kg N/ha.

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استجابة المحصول، ومكوناته، ونسبة الزيت للاختلاف في صنف السمسم، ومعدل التسميد النيتروجيني بمنطقة مكة المكرمة

فتحي سعد النخلاوي ومحمد عبد الرحيم شاهين

قسم زراعة المناطق الجافة – كلية الأرصاد والبيئة وزراعة المناطق الجافة

جامعة الملك عبد العزيز – جدة – المملكة العربية السعودية

المستخلص. أجريت تلك الدراسة بمحطة الأبحاث الزراعية التابعة لجامعة الملك عبد العزيز بهدا الشام خلال موسمي ٢٠٠٧، ٢٠٠٨م وذلك بهدف دراسة إنتاجية محصول السمسم في منطقة مكة المكرمة من خلال دراسة تأثير أربعة معدلات من التسميد النيتروجيني هي: صفر، و١٠٠، و١٥٠، و٢٠٠كجم نيتروجين/ هكتار على محصول البذور، ومكونات المحصول، ونسبة الزيت في ثلاثة أصناف من السمسم هي: السعودي المحلي، والصنف المصري "شندويل"، والصنف السوداني "سودان-١"، وذلك في التصميم الإحصائي القطع المنشقة Split-Plot Design بأربعة مكررات، حيث كانت معدلات التسميد النيتروجيني هي معاملات القطع الرئيسية، والأصناف هي معاملات القطع المنشقة. وقد أوضحت نتائج تحليل التباين المشترك للموسمين، أن التفاعل بين معدلات التسميد النيتروجيني والأصناف، كان ذا تأثيرات معنوية على موعد التزهير، وارتفاع النبات، وعدد الأفرع/نبات، وعدد الثمار/نبات، ووزن البذور/نبات، ومحصول البذور للهكتار، في حين لم يظهر تأثير معنوي للتفاعل على نسبة الزيت بالبذور، أو التسميد النيتروجيني، أو الأصناف على نسبة الزيت. وكان الصنف

السعودي المحلي تحت معدلي التسميد النيتروجيني ١٥٠كجم، و٢٠٠كجم نيتروجين/هكتار هو الأعلى محصولا للبذور/هكتار، باختلاف معنوي عن بقية المعاملات الأخرى، حيث أنتج ٨٦٢,٤٧ كجم بذرة/هكتار، و٨٦٩,٤٥ كجم بذرة/هكتار تحت تأثير المعدلين السابقين على التوالي. يلي ذلك الصنف شندويل، تحت تأثير معدلي التسميد النيتروجيني ١٥٠كجم، و٢٠٠كجم نيتروجين/ هكتار، حيث أنتج ٧٣٣,٣٧ كجم بذرة/هكتار، و٧٢٩,٨٩ كجم بذرة/هكتار تحت معدلي التسميد السابقين على الترتيب. بينما كانت إنتاجية الصنف سودان-١ هي الأقل معنويًا تحت معدلات التسميد المختلفة، ونفس الاتجاه لسلوك صفات مكونات المحصول، فقد سلكت نفس السلوك مثل صفة المحصول/هكتار، وأظهرت نتائج نسبة الزيت في الأصناف، أن نسبة الزيت كانت (٤٥,٣٧٪) للصنف السعودي المحلي، و(٤٥,٩٦٪) في الصنف شندويل، و(٤٥، ٨٠٪) في الصنف سودان-١.