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RESPONSE OF SESAME TO POPULATION DENSITIES AND NITROGEN FERTILIZATION ON NEWLY RECLAIMED SANDY SOILS

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Abstract

Two field experiments were conducted at the Experimental Farm of Faculty of Agriculture, Suez Canal University at Ismailia during 2008 and 2009 seasons to study the effect of nitrogen fertilization and planting density on growth , yield, its attributes as well as seed quality of new sesame variety (Taka 2 cv.). On newly reclaimed sandy soils of Ismailia Governorate, Egypt, experimental design in split plots form with four replications was used. Four levels of nitrogen fertilization 55, 105, 155 and 205 Kg/ha were arranged randomly in the main plots and three planting distances between hills (10, 15 and 20 cm, respectively) were distributed at random in the sub plots. Increasing N fertilizer level up to 205 Kg/ha significantly increased plant height, fruiting zone length, height of the first fruiting branch, number of branches and capsules/plant, 1000-seed weight, seed weight/plant, seed oil content (%) and seed and oil yields /ha. Decreasing planting distance from 20 to 15 and 10 cm consistently and significantly increased plant height, height of the first fruiting branch and seed and oil yields /ha. The reverse was true regarding the yield components. These results were expected, since experiment soil was newly reclaimed sandy soil and very poor in the nutrients and organic matter.

Introduction

Sesame (*Sesamum indicum* L.) is considered as one of the most important oil crop in the world because its seeds have high contents of oil and protein. In Egypt most of the seed production is consumed as edible products such as Tehena, Halawa tahiniya and bakery products. The total production of edible oil is about 10% of the consumption in Egypt. Therefore many attempts are being made to raise total production of oil crops particularly sesame for narrowing oil deficiency gap. Today, India and China are the world's largest producers of sesame, followed by Myanmar, Sudan, Uganda, Nigeria, Pakistan, Tanzania, Ethiopia, Guatemala, Turkey and Egypt. In Egypt expanding area under sesame should be taken in newly, reclaimed sandy soils, which is facing many problems like low fertility, poverty and high loss of nutrients by leaching.

Nitrogen is the most important essential nutrient in plant nutrition. It is a constituent of a large number of necessary organic compounds such as amino acids, proteins, coenzymes, nucleic acids, ribosomes, chlorophyll, cytochrome and some vitamins Marschner (1986) and Noorka *et al*., (2009). Several investigators reported the positive effects of applying nitrogen fertilization on growth, yield attributes, seed yield and quality of sesame. Basha (1994) found that number of capsules/plant, seed index, seed weight/plant and seed and oil yields/ha were increased by raising N from 35.70 to 178.50 kg/ha, but the oil content % was decreased. Bassiem & Anton (1998) observed that yield components were increased by escalating N doses from 71 to 142 Kg/ha, while seed yield/ha was augmented up to 214 Kg /ha. Nevertheless, the low level of N (71 Kg /ha) produced the highest seed oil content %. Fayed *et al*., (2000) detected that plant height, height of first capsule, number of capsules/plant, seed weight/plant and seed yield/ha were increased by raising N fertilization from 71 to 142 Kg/ha**.** Also, Ashfaq *et al*., (2001) demonstrated that plant height, number of branches and capsules/plant, seed index and seed yield/ha were increased by increment N up to 120 Kg/ha. Optimum plant density and efficient screening technique to select best parent (Noorka & Khaliq, 2007) is considered very important for obtaining the maximum yield especially with new varieties such as Taka 2 cv due to excessive space to grow and florish however low plant density may spoil on-farm inputs. Several researchers studied optimum population density in sesame such as Ahmad *et al*., (2002) sowing sesame at spaces 30, 45 and 60 cm between plants and reported that 45 cm apart was the best distance for plant height and seed yield /ha. Rahnama & Bakhshandeh (2006) revealed that planting sesame at 37.5, 50 and 60 cm space between plants than number of capsules/plant, seed index, seed weight/plant and oil concentration were increased by increment plant distance up to 60cm. Karaaslan *et al*., (2007) used the four row spacing were alternating rows of 50-30, 70-30, 80-40 cm in 6 row-plots and 70-70 cm in 4 row- plots and found that decreasing row spacing increased seed yield/ha, but number of capsules/plant was decreased. Roy *et al*., (2009) sowed sesame at 15, 30 and 45 cm between plants and observed that seed yield/ha and yield components were increased by raising planting space from 15 to 30 cm.

Materials and Methods

Two field experiments were conducted during 2008 and 2009 seasons at the Experimental Farm, Faculty of Agriculture, Suez Canal University at Ismailia to study the effect of nitrogen fertilization and plant density as planting distances between hills on growth, yield, yield components and seed quality of new sesame variety (Taka 2 cv.). Taka 2 variety was achieved by Nuclear Research Center, Atomic Energy Authority in Egypt. Fertilizer in the shape of nitrogen ammonium nitrate (33.5% N) was applied at three equal doses, after thinning, 35 and 50 days from sowing. A basal dose of calcium super-phosphate fertilizer (15.5% P_2O_5) was added @ 476 kg/ha at two equal doses, during preparing experimental soil and after thinning (mixed with

the surface of soil) and 357 kg/ha of potassium sulphate (48% K_2O) were applied at three equal doses, after thinning, 50 and 65 days from sowing. The normal cultural practices for growing sesame crop at Ismailia were followed. The soil of the experimental site was sandy with pH values 7.61 and 7.55 and contained 3.15 and 3.44 ppm while available N, 1.80 and 1.86 ppm available P, 11.65 and 11.90 ppm available K and 0.049 and 0.058% organic matter in the two seasons, respectively (Chapman & Pratt, 1961, Watanabe & Olson, 1962).

Every experiment included 12 treatments which were the combination of four levels of nitrogen fertilization viz., i.e., 55, 105, 155 and 205 Kg N/ha and three planting distances between hills i.e., 10, 15, 20 cm resulting 400000, 266666 and 200000 plants/ha, respectively. The treatments were arranged in split plot with four replications. Four levels of nitrogen fertilization were arranged randomly in the main plots and three planting distances between hills were distributed at random in the sub plots. Seeds of sesame Taka 2 variety were sown @ 2.5 pound per acre by hand on one side of the ridge on May 5 and 7 in 2008 and 2009 seasons, respectively. After 23 days from sowing, sesame plants thinning were made to two plants per hill.

At harvest time, after 115 days from sowing, samples of 10 guarded plants were randomly taken from the inner ridges in each sub plot to estimate plant height (cm), height of the first fruiting branch (cm), fruiting zone length (cm), number of branches and capsules/plant, 1000-seed weight (g) and seed weight/plant (g). Seed yield (ton/ha) was determined from the plants of the two middle ridges (the 3rd and 4th ridges) in each plot and the yield per hectare was calculated. Seed oil content (%) was determined by using Soxhlet continuous extraction apparatus with petroleum either as an organic solvent according to A.O.A.C. (1975) and seed oil yield (ton /ha) was calculated by multiplying oil percentage and seed yield per ha.

The analysis of variance of split plots design was used according to Snedecor & Cochran (1982). Means were compared for significant according to Duncan's Multiple Range Test at 5% level of significance (Duncan, 1955). Alphabetical letters were applied to distinguish transactions and according to the presence or not of statistical differences not statistically different

Results and Discussion

Effect of nitrogen fertilization: Data in (Table 1) illustrate that increasing nitrogen fertilizer level up to 205 kg N/ha consistently and significantly increased plant height, height of the first fruiting branch and fruiting zone length. The differences between the four levels of N were significant and that was true in 2008 and 2009 seasons. These results were expected since nitrogen stimulates cell division and extension in turn increases number and length of internodes resulting in taller plants. Confirming results were detected by Bassiem & Anton (1998) up to 142 Kg N/ha**,** Ali (2002) up to 178.5 Kg N/ ha and Muhamman & Gungula (2008) up to 90 Kg N/ ha.

Number of branches per plant was increased significantly by increasing N rate from 55 to 205 kg/ha in the two growing seasons (Table 2). That might be due to the fact that N encourages the meristematic activity and photosynthesis rate, which produced more number of branches/plant. In this respect, Ashfaq *et al*., (2001) noted similar finding by applying N up to 120 Kg/ha and El-Mahdi (2008) up to Kg 40 N/ha.

Applying nitrogen fertilizer produced more number of capsules/plant of sesame and the differences between the four levels of N (55, 105, 155 and 205 kg N/ ha) were significant in 2008 and 2009 seasons (Table 2). The increase in number of capsules/plant might be due to the favorable effect of N on the amount of metabolites synthesized and pods setting. In this respect, Fayed *et al*., (2000) with 142 Kg N/ha Muhamman *et al*., (2009) with 90 Kg N/ha showed similar results.

Table 1. Effect of nitrogen fertilization and planting distance on plant height, height of the first fruiting branch and fruiting zone length of sesame through 2008 and 2009 seasons.

Treatments	Plant height (cm)		Height of the first fruiting branch (cm)		Fruiting zone length (cm)	
Seasons	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
			Nitrogen fertilization (N)			
55 Kg N/ha	133.67 d	153.33 d	36 d	37.41 d	57 d	60.34 d
105 Kg N/ha	151.67 c	164.66 c	42.56 c	43.9 c	60.73 c	64.13 c
155 Kg N/ha	168.67 b	180.33 b	46.67 b	48.95 b	65.77 b	69.74 b
205 Kg N/ha	177 a	192 a	51.33 a	52.85 a	67.21 a	71.80 a
F- test	*	*	*	*	*	*
			Distance between hills (D)			
10 cm (400000 plants/ha)	163.25 a	181 a	47.5 a	49.52 a	58.32 c	61.79 c
15 cm (266666 plants/ha)	158.50 b	172.25 b	44 b	45.76 b	63.20 b	67.15 b
20 cm (200000 plants/ha)	151.50 c	164.50 c	40.92 c	42.05 c	66.50 a	70.57 a
F- test	*	*	*	*	*	*
Interaction N x D	NS	*	NS	*	NS	NS

NS,*=non-significant and significant probability level at 5%, respectively.

Data in (Table 2) indicated that 1000-seed weight of sesame significantly increased by increasing N level up to 205 Kg N/ha in 2008 and 2009 seasons. The favorable effect of nitrogen fertilizer on 1000-seed weight may be due to the reason that N stimulated plant growth such as plant height and number of branches/plant, which increased that amount of light energy intercepted by leaves. In addition, N increased photosynthetic pigments content and photosynthesis rate, which in turn increased the amount of metabolites synthesized and consequently resulted in higher dry matter accumulation in leaves and partitioned to seeds. These results are in harmony with those reported by Basha (1994) and Malik *et al*., (2003) with adding N fertilizer up to 178.5 Kg/ha, and 80 Kg/ha, respectively.

Fertilizing sesame plants with 205 kg N/ha produced the heaviest weight of seeds/plant with significant differences between the four levels of nitrogen fertilizer and that was true in the two growing seasons as shown in (Table 3). These results were expected, since N encouraged plant growth, number of capsules/plant and 1000-seed weight in turn increased seed weight/plant. These results are in agreement with each of Fayed *et al*., (2000) and Muhamman *et al*., (2009) who found that seed weight/ plant was increased by adding N fertilizer up to 142 and 90 Kg /ha, respectively.

Table 2. Effect of nitrogen fertilization and planting distance on number of branches /plant, number of capsules /plant and 1000-seed weight of sesame through 2008 and 2009 seasons.

Treatments	Number of branches /plant		Number of capsules /plant		1000-seed weight (g)	
Seasons	2008	2009	2008	2009	2008	2009
	Nitrogen fertilization (N)					
55 Kg N/ha	7.80 d	8.59 d	49.33 d	67.52 d	2.82 d	2.80 d
105 Kg N/ha	9.27 c	9.99 c	68.67 c	80.78 c	3.02 c	3.03 c
155 Kg N/ha	10.80 b	11.59 b	85.33 b	94.70 b	3.31 b	3.42 b
205 Kg N/ha	12.17 a	13.02 a	97.65 a	106.03 a	3.63 a	3.75 a
F- test	*	*	*	*	*	*
	Distance between hills (D)					
10 cm (400000 plants/ha)	9.52 c	10.3 c	69.49 c	81.95 c	3.10 c	3.15 c
15 cm (266666 plants/ha)	9.97 b	10.97 b	75.75 b	87.54 b	3.19 b	3.25 b
20 cm (200000 plants/ha)	10.52 a	11.31 a	80.50 a	92.09 a	3.29 a	3.35 a
F- test	*	*	*	*	*	*
Interaction N x D	NS	NS	*	*	*	*

NS, * = non-significant and significant probability level at 5%, respectively

Table 3. Effect of nitrogen fertilization and planting distance on seed weight/ plant, seed yield/ha, seed oil content (%) and oil yield /ha of sesame through 2008 and 2009 seasons.

Treatments	Seed weight/ plant (g)		Seed yield/ha (ton)		Seed oil content (%)		Oil yield /ha (ton)	
Seasons	2008	2009	2008	2009	2008	2009	2008	2009
	Nitrogen fertilization (N)							
55 Kg N/ha	9.23 d	11.18 d	1.285 d	1.628 d	58.19 a	58.98 a	0.747 d	0.950 d
105 Kg N/ha	11.51 c	13.60 c	1.622 c	1.974 c	53.92 b	54.83 b	0.866 c	1.073 c
155 Kg N/ha	14.19 b	16.51 b	2.008 b	2.334 b	52.57 c	53.30 c	1.044 b	1.228 b
205 Kg N/ha	17.19 a	18.69 a	2.442 a	2.691 a	52.20 d	52.86 d	1.264 a	1.406 a
F- test	*	*	*	*	*	*	*	*
	Distance between hills (D)							
10 cm (400000 plants/ha)	12.11 c	14.04 c	2.419 a	2.728 a	50.70 c	51.08 c	1.214 a	1.382 a
15 cm (266666 plants/ha)	13.03 b	15.04 b	1.699 b	2.108 b	55.13 b	55.93 b	0.934 b	1.171 b
20 cm (200000 plants/ha)	13.96 a	15.90 a	1.405 c	1.631 c	56.82 a	57.97 a	0.792 c	0.939 c
F- test	*	*	*	*	*	*	*	*
Interaction N x D	NS	NS	NS	NS	NS	NS	NS	NS

NS, * = non significant and significant probability level at 5%, respectively

It is clearly evident from (Table 3) that seed yield/ha increased significantly and consistently as N fertilizer rate was increased up to 205 Kg N/ha in both seasons (2008 and 2009). The positive effect of increasing N fertilizer level on seed yield/ha of sesame might be attributed to the beneficial role of nitrogen on stimulating plant growth. Plant traits plant height, number of branches/plant and fruiting zone length, which reflects favor on yield attributes *i.e.* capsules number/plant, 1000-seed weight and seed weight/plant in turn increased seed yield/ha. Many researches reported increasing in seed yield/ha by applying N fertilizer up to 178.5, 178.5, 214, 40, 142, 80 and 90 Kg N/ha (Basha, 1994; Ali, 2002; Bassiem & Anton, 1998; El-Mahdi (2008); Fayed *et al*., 2000 Malik *et al*., 2003 and Muhamman & Gungula, 2008), respectively.

Seed oil content (%) was negatively and significantly affected by increasing N rate up to 205 kg N/ha and that held true in both seasons (Table 3). These results were expected since the low nitrogen rates resulted in smaller seeds (1000-seed weight) and this might be on the expense of carbohydrate storage rather than oils, which resulted in increasing percentage of the laters. These results are in a same trend with those found by Basha (1994) who recorded that seed oil content (%) increased by decreasing N level from 178.5 to 35.7 Kg/ha. Bassiem & Anton (1998) reported from 214 to 71 Kg/ha and Ali (2002) from 178.5 to 71 Kg/ha.

Table 3 shows that increasing nitrogen fertilizer level up to 205 kg N/ ha significantly increased oil yield/ha in 2008 and 2009 seasons. The increase in oil yield/ha by increasing nitrogen rate might be mainly due to the increase in seed yield/ha regardless the negative effect of that on seed oil percentage. Confirming results were emphasized by Basha (1994) and Ali (2002) with 178.5 Kg N/ha.

Effect of plant density: Data in (Table 1) showed that increasing plant population density from 200000 to 266666 and 400000 plants/ha by decreasing planting distance between hills from 20 to 15 and 10 cm significantly increased plant height, height of the first fruiting branch. That was true in the two growing seasons. These results might be due to the higher competition among plants, for light in dense plant population, which may results elongation of internodes and in turn gave taller plants. Ahmad *et al*., (2002), obtained similar results with 30 cm between hills.

Increasing planting distance between hills up to 20 cm significantly increased fruiting zone length in 2008 and 2009 seasons (Table 1). These results were expected because of low competition among plants for moisture, nutrients and light in wide planting distance, which increased potentiality of plants in increasing fruiting zone length (Ahmad *et al*., 2002; Khan *et al.*, 2010; Shah *et al.*, 2010; Arif *et al.*, 2011.).

It is obvious from (Table 2) that distances between hills exhibited significant effects on number of branches and capsules /plant as well as 1000-seed weight of sesame. There were consistent and remarkable increases in the aforementioned characters as planting distance was increased from 10 to 15 and 20 cm and that was true in 2008 and 2009 seasons. These results were expected since that in wide planting distance there was a low competition among plants for growth factors such as moisture, nutrients, space and light, which in turn increased potentiality of sesame plants in producing more branches and capsules per plant as well as heavier 1000-seed weight. These results are in accordance with those found by Rahnama & Bakhshandeh (2006) with 60 cm apart. Moreover, Karaaslan *et al*., (2007) found that increasing row width from 50-30 to 80-40 cm increased the mentioned characters.

Decreasing plant population density by increasing planting distance between hills from 10 to 15 and 20 cm gave significant increases in seed weight/plant of sesame in 2008 and 2009 seasons (Table 3). Such effect might be due to the increase in capsules number/plant and 1000-seed weight with wide distance between hills. Similar results were reported by Rahnama & Bakhshandeh (2006), who observed that seed weight/plant was increased by increasing plant distance upto 60 cm.

Data in (Table 3) shows that increasing plant population density up to 400000 plants/ha via decreasing planting distance up to 10cm increased seed yield/ha significantly and consistently in the two growing seasons. Sowing sesame plants at close distance of 10cm out yielded 15 and 20 cm in seed yield/ha by 42.35% and 72.15% in the first season and 29.40% and 67.25% in the second one, respectively.

It is worthy to mention that increases in seed yield per ha at highest plant population density might be due to that the greater number of sesame plants per unit area in narrow distance between hills could compensate that reduction in yield attributes of the individual plants such as number of capsules/plants, 1000-seed weight and seed weight/ plant. It is important that the unit land area not the individual plant, produces its maximum yield. These results are in harmony with those reported by Ahmad *et al*., (2002), Rahnama & Bakhshandeh (2006), who found that the highest seed yield/ha was produced with planting distance of 45 cm and 30 cm between hills, respectively.

Seed oil content (%) of sesame was inversely related to increasing plant density as shown in (Table 3). There was significant increase in seed oil percentage by decreasing plant density up to 200000 plants/ha. May be the lack of the number of plants per unit area helps the growth of plants that are good for the availability of fertilizer nutrients, water and air, thereby increasing the accumulation of food ingredients in seeds as part of the economic yield and oil content of seeds. These results are in agreement with those recorded by Rahnama & Bakhshandeh (2006) who found that seed oil percentage increased by increment in planting distance up to 60 cm.

Table 3 illustrates that increasing plant density up to 400000 plants/ha through decreasing planting distance up to 10 cm gave significant increase in oil yield/ha in 2008 and 2009 seasons. The increase in oil yield/ha with higher plant population density are mainly due to the increase in seed yield per ha confirming results reported by Rahnama & Bakhshandeh (2006).

Moreover, previous studies have confirmed obtained results regarding positive response of N fertilization. Researchers like Ali (2002) reported 71, 107, 142 and 178.5 Kg N/ha, Malik (2003) 0, 40 and 80 Kg N/ha, El-Mahdi (2008) 40 Kg N/ha, Muhamman & Gungula (2008) and Muhamman *et al*., (2009) with 0, 30, 60 and 90 Kg N/ha.

Interaction effect: Data in (Table 4) shows that there was significant interaction effect between nitrogen fertilization and plant density on number of capsules/plant and 1000-seed weight in the two growing seasons. The highest number of capsules/plant (110 and 102) and heaviest 1000-seed weight (3.89 and 3.78 g) were obtained during 2008 and 2009 seasons respectively. These were produced by sowing sesame plants in hills spaced 20 cm apart and applying 205 kg N/ha. The lowest values of the aforementioned characters (60.05 and 43 capsules/plant) and (2.75 and 2.80 g) in the two seasons, respectively were achieved by planting sesame plants in hills spaced 10 cm apart and adding 55 kg N/ha (Table 4 and Figs. 1 and 2).

Table 4. Effect of the interaction between nitrogen fertilization and planting distance on number of capsules /plant and 1000-seed weight (g) of sesame through 2008 and 2009 seasons.

N (Kg/ha)	1000-seed weight (g)						Number of capsules /plant					
	2009			2008			2009			2008		
	Planting distance			Planting distance			Planting distance			Planting distance		
	20 cm	15 cm	10 cm	20 cm	15 cm	10 cm	20 cm	15 cm	10 cm	20 cm	15 cm	10 cm
55	2.86	2.81	2.80	2.85	2.80	2.75	55.00	50.00	43.00	73.46	68.24	60.05
105	3.11	3.02	2.92	3.12	3.03	2.93	75.00	69.00	62.00	86.10	80.75	75.50
155	3.43	3.32	3.19	3.54	3.43	3.30	90.00	86.00	80.00	98.80	94.46	90.84
205	3.78	3.63	3.48	3.89	3.75	3.62	102.00	98.00	92.96	110.00	106.70	101.40
0.058		0.065			6.35			8.15			LSD 0.05	

Conclusion

It is worthy mention that the highest seed and oil yields per ha of sesame crop were produced by sowing plants at 10 cm and fertilizing with 205 Kg N/ha in newly reclaimed sandy soils in Egypt. On the other hand, the bio, phosphorus and potassium fertilization is considered very important under these sandy poor soils conditions.

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