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Effect of Different Plant Density on Growth and Yield of Three Cultivars of Sesame (*Sesamum indicum* L.)

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ABSTRACT: Sesame is one of the oldest and most important oil seed crop. Field experiment was carried out to investigate the effect of plant density on growth and yield of three cultivar of sesame (*Sesamum indicum* L.). This research conducted at field of Agricultural Training School in Sari, 2013. Three cultivars of sesame (Naz, Yekta and Oltan) were assigned to the main plots and row spacing (40, 50 and 60 cm) were assigned to the subplots with 4replications. The results showed that cultivar treatments significantly effect on traits such as, plant height, the number of capsule per plant, yield per plant, harvest index, seed oil percentage, seed yield, seed protein percentage and protein yield. Plant density had significantly effect on plant height, seed yield per plant and the number of seed per plant. Also, the results indicated that Yekta cultivar as parameters such as, plant height, the number of capsule per plant, the number of seed per capsule, seed yield, oil yield and protein yield was the best cultivar. The highest harvest index and yield per plant observed by Naz cultivar.

Key words: Sesame (*Sesamum indicum* L.), Cultivars, Growth, Oil yield.

INTRODUCTION

Sesame (*Sesamum indicum L.)* from Pedaliaeace family is an oil seed crop that has been grown since ancient times. Sesame seed has the highest oil content of any seed. It grows well in tropical and subtropical areas, while its yield performance is relatively high in temperate climate (Alegbejo *et al.,* 2003). Sesame is not only an oil-rich seed (42-45%) but also in protein (20%) and carbohydrates (14-20%). Also sesame seeds contain 50-60% oil which has excellent stability due to the presence of the endogenous antioxidants sesamol and sesaminol in combination with tocopherols (Ball *et al.,* 2000).In Iran near to 34 thousands hectare were allocared to sesame with 25 thousand kilograms of seed production and 729 kilograms per hectare mean yield. In Mazandaran province because of the diversity of cultures, sesame as the main crop in the spring or in intercropping with cotton in the spring, as well as a second crop after harvest grain crops are grown.

The crop is grown under a range of environments, which probably affects its performance. The environmental factors that influence sesame productivity include climatic factors such as temperature, rainfall and day length, soil types and management practices such as plant densities, time of sowing, irrigation, fertilizers, herbicides and fungicides, some of which may partially mitigate others. In particular, population density plays a cardinal role in determining seed yield (Malik *et al.,* 2003). Hence, identification of optimum population for each variety being tested becomes vital. The effect of plant population on yield and yield components have been reported by several workers. 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^{-1}. Rahnama and 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 60 cm. The objectives of this study, therefore, were to investigate the influence of population densities on seed yield, and yield components of sesame.

MATERIAL AND METHOD

The field experiment was conducted at field of Agricultural Training School in Sari (36°33´N, 53°3´E) located in the northern of Iran at an altitude of about 25.7 metres above sea level, 2013. Experimental field has wet climate, average rainfall during the growing season, 759.72 mm. The soil of the experimental fields was clay loam. Soil test results are shown in Table 1. According to soil test results, sesame cultivation has faced a shortage of nitrogen.

Table 1: Physical and chemical properties of the experimental site soil.

	Soil texture	Organic material			(pH)	EC (ds/m^{-1})	OC (%)
		K (ppm)	P (ppm)	N (%)			
Field soil	Clay loam	419	28.4	12	7.6	0.41	1.52

The experimental design was splitplotina randomized complete block design with six treatments. Three cultivars of sesame (Naz, Yekta and Oltan) were assigned to the main plots and row spacing (40, 50 and 60 cm) were assigned to the subplots with 4 replications. Each plot size was 3 × 4 meters and the length and width of experimental field respectively, 50and20meters.The distance between the plots was 1m and distance between replications was 1.5 m. Thus, the total land area for this experiment was 1000 m^2. The site was previously cropped to Spinach (*Spinacia oleracea*). The land was harrowed with a tractor-driven disc and plots manually prepared. On 2 of June N fertilization was performed during land preparation. On 5 of June seeds were sown at the specified spacing.

Plots were harvested by hand at the stage of full ripeness. The mature plants were harvested when the color of the leaves changed from green to yellow; stacked in an upright position to avoid shattering of seeds and allowed to dry under the sun in the field. In this research height, dry weight, number of capsules per plant, number of seeds per capsule, seed weight, seed yield, biological yield and harvest index were measured.

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 protein content was determined by using Khejdal method (% protein = % nitrogen in seed × 6.25). Seed oil yield (kg ha^{-1}) and protein yield (kg ha^{-1}) were calculated by multiplying oil and protein percentage with seed yield per ha. Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis Agricultural Sciences (SAS) and MSTAT-C program.Data means were compared by Duncan's Multiple Range Test at P=0.05. The EXCEL Microsoft word was used for drawing of diagram.

RESULT AND DISCUSSION

Results showed plant density and cultivars had significantly effect on plant height (Table 2). The maximum and minimum height recorded in Naz and Yekta cultivars, respectively, because of genetics influences. However, Oltan cultivar due to several branches had average height. The greater plant height in all cultivar recorded in 60 cm plant density (Table 3).

Table 2: Analysis of variance for the effects of plant density on growth and yield of sesame (*Sesamum indicum*).

S.O.V	d.f	Plant height	Number of capsules plant^{-1}	Number of seed capsule^{-1}	1000-seed weight	Seed yield plant^{-1}	Seed yield	Harvest index
Cultivar (A)	2	11327.69**	4231.86**	1181.08**	0.085$^{n.s.}$	12.95**	29409.01**	438.11**
Error	3	4.55	17.30	24.91	0.03	1.25	1946.68	6.36
Plant density (B)	2	560.44**	3.69$^{n.s.}$	96.75*	0.006$^{n.s.}$	14.12**	6340.61$^{n.s.}$	4.54$^{n.s.}$
A×B	4	8.82$^{n.s.}$	339.82**	42.33**	0.008$^{n.s.}$	0.77**	294095.01**	61.29 **
Error	12	4.84	11.56	23.19	0.02	0.2	3213.83	3.56
C.V (%)	-	1.37	3.4	7.5	6.41	10.57	3.38	10.62

** Significant at 1% level, * significant at 5%, n.s. no significant

Ahmed *et al.* (2005) stated that an increase in planting population markedly would increase plant height. Morrison *et al.* (1995) suggested that plant density caused to increasing intra specific competition and fewer branches generated by stimulating apical meristem and increasing plant height to receiving sunlight. Ozoni Davaji *et al.* (2007) also contributed the increasing height is affected by inter nodes growth resulting from producing Giberline hormone under light deficit conditions. The environmental factors such as the quantity and quality of light prompt plant height increase in higher plant densities, particularly in unequidistant plant distribution. The level of light, as well as the red and far red ratio, plays an important role in stem elongation and consequently on final plant height.

Significant differences were found between the three varieties in the number of capsules per plant (Table 2). The Oltan cultivar produced more number of capsules per plant (115.5) than other varieties (Table 3). The number of capsules per plant is one of the main components that determine crop yield potential. This trait affected by genetic factors. Ahmed *et al.* (2002) Stated that the reduction in numbers of sesame density, sub-branches and number of capsules per plant increased, it may be due to increased dry matter accumulation and lack of competition between adjacent plants.

Varieties were significantly affected by plant density for the number of seeds per capsule (Table 2). The cultivar Yekta produced the highest number of seeds capsule^{-1} (74.25) and the variety Oltan produced the lowest number of seeds capsule^{-1} (54.42) (Table 3). These findings corroborated with those reported in Kathiresan (2002). Decrease in plant density increased intra specific competition which eventually caused reduction in the number of seeds capsule.

Thousand seed weight had no affected by plant density and varieties (Table 2). As shown in Table 3, maximum 1000-seed weight recorded in Oltan cultivar, and 50 cm plant density had more effected on 1000 seed weight. Onwueme and Sinha (1991) reported that as plant population increased, the seed size decreases. That is really expected because the number of capsule per plant and seed yield per plant, had significant positive phenotypic and genotypic correlation with 1000-seed weight and yield per hectare, indicating that the seed yield per plant was also positively and significantly correlated with 1000-seed weight and yield per hectare. Increases in each character; leaf weight, number of branches and number of capsules in plant contribute to an incremental increase to the 1000-seed weight. Because improving stem number increases the number of leaves on a plant, which raises the chlorophyll level and thus facilitates more photosynthesis, providing the plant with more food, which in turn affects seed weight and volume. Paperi and Bohrani (2005) concluded that decreasing the density increases capsule weight and numbers in the plant from a study on the nitrogen operation and plant density of sesame.

Table 3: Mean comparison of growth and yield of sesame (*Sesamum indicum*).

Treatment	Plant height (cm)	Number of capsules plant^{-}	Number of seed capsule^{-1}	1000- seed weight (gr)	Seed yield plant^{-1} (gr)	Seed yield (kg)	Harvest index
Cultivars							
Yekta	190.5 a	115.5 a	74.25 a	2.5 a	3.09 b	2217.15 a	17.6 a
Oltan	162.2 b	79.08 c	54.42 a	2.67 a	3.59 c	1235.37 c	13.5 c
Naz	127.6 c	107.5	64.34 b	2.65 a	6.71 a	1887.64 b	24.8 a
Plant density							
40	153.58 c	100 a	65.1 a	2.58 a	2.25 c	1709.9 a	17.1 a
50	156.12 b	100 a	67.8 a	2.63 a	4.1 b	1708.8 a	16.78 a
60	167.27 a	100 a	60.02 b	2.62 a	5.4 a	1704.46 a	17.89 a

Within a column, means with the same letter are not significantly different by Dunkan's test.

Seed yield in sesame is a function of capsule length, capsules plant^{-1} and seeds capsule^{-1} (Rahman *et al.*, 1995). It was observed that there was significant difference in seed yield plant-1among the varieties tested. The cultivar Naz produced the highest seed yield plant^{-1} (6.71 g) and the cultivar Yektaproduced the lowest seed yield plant^{-1} (3.09 g). Lower plant density (40 cm) gave lower seed yield plant^{-1} (2.25 g). Higher seed yield plant^{-1} (5.4 g) was recorded in the highest spacing (60 cm) (Table 3). Low plant density reduced seed yield plant^{-1} due to inter and intra plants competition for necessary resources required for growth and development of seed. Also with increasing plant density, each plant tries to improve its branches using more environmental resources due to competition. This leads to making more materials and transferring lots of Asimile toward aerial members especially to the seeds, producing bigger seeds and better seed yield.

The observed yield improvement was probably due to increased leaf area index from the better use of sun light that boosted photosynthesis in the growing season. But the most important reason for yield improvement with increased density can be attributed to the number of plants growing in a field unit (Moosazadeh *et al.* 2010). Momoh and Zhou (2001) showed that seed yield of canola significantly increased by increasing plants density. The effect of plant density on seed yield per hectare was not significant (Table 2). This result supports the recent study by Norooz Poor and Rezvani (2005).

Plant density had no effected on harvest index of sesame cultivars but cultivars had significantly effect on sesame harvest index (Table 2). Among all cultivar the highest harvest index obtained by Naz cultivar (24.8) and lowest observed by Oltan cultivar (13.5). Increased harvest index in Naz cultivar due to lack of sub branches (Table 3).

Cultivar had significantly effect on seed oil percentage and oil yield, while plant density had no effect on these traits (Table 4).Among all cultivars, Oltan cultivar had maximum oil percentage. The higher oil percentage of Oltan cultivar because the color of Oltan seed was darker than other cultivar. Among cultivars, Yekta cultivar and Oltan cultivar possessed respectively the maximum and minimum oil yield (Table 5). Also results indicated that increasing plant density decrease oil percentage. 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 and Bakhshandeh (2006) who found that seed oil percentage increased by increment in planting distance up to 60 cm.

Analysis of variance (Table 4) indicated that effects of plant density and on seed protein percentage and protein yield non-significant. Cultivar effects were significant for seed protein percentage and protein yield of sesame., Yekta cultivar and Oltan cultivar possessed respectively the maximum and minimum seed protein percentage (Table 5). Studies showed that the effect of genes and environment on seed protein content is effective. Sesame seed has an average of 45% oil and 19-25% protein, but these amounts depend on their cultivar and the environmental factors Weiss (1983) reported that oil content is negatively correlated with protein content.

Table 4: Analysis of variance for the effects of plant density on oil and protein percentage and yield of sesame (*Sesamum indicum*).

S.O.V	d.f	Seed oil percentage	Oil yield	Protein percentage	Protein yield
Cultivar (A)	2	498.86**	256444.33**	59.70**	184861.52**
Error	3	2.96	7431.21	0.62	1785.52
Plant density (B)	2	0.86$^{n.s.}$	4804$^{n.s.}$	0.16$^{n.s.}$	560.69$^{n.s.}$
A×B	4	10.74$^{n.s.}$	31716.58**	6.65**	14020.24**
Error	12	8.13	3006.44	0.25	1554.55
C.V (%)	-	6.03	7.12	2.13	10.23

** Significant at 1% level, * significant at 5%, n.s. no significant

Table 5: Mean comparison of oil and protein percentage and yield of sesame (*Sesamum indicum*).

Treatment	Seed oil percentage	Oil yield	Seed protein percentage	Protein yield
Cultivars				
Yekta	44.76 b	895.75 a	25.79 a	506.63 a
Oltan	55.7 a	609.92 c	24.45 b	258.58 c
Naz	44.1 b	806.54 b	21.32	401.2 b
Plant density				
40	48.1 a	784.4 a	24.7 a	400 a
50	48.5 a	789.9 a	24.4 a	399.6 a
60	48.4 a	796.1	24.2 a	395.a a

Within a column, means with the same letter are not significantly different by Dunkan’s test.

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