Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

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Asian Journal of Plant Sciences 3 (5): 610-613, 2004
ISSN 1682-3974

Effect of Planting Method and Plant Population on Growth and Yield of Sesame (*Sesamum indicum* L.) in a Mediterranean Type of Environment

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Abstract: The effects of planting method (row and broadcast) and plant population (102 000, 127 500, 170 000, 255 000 and 510 000 plants ha^{-1}) on yield and yield components of sesame were studied under irrigated conditions in the East Mediterranean region of Turkey during 2002 and 2003. Seed yield and yield components of sesame were significantly affected by planting methods. The row planting had positive effects on yield and yield components and produced around 34% higher seed yield comparing to broadcast planting in both years. The population density also significantly affected to all growth and yield parameters. Plant height, branch number, capsule number, capsule length, seed number per capsule, seed weight, seed yield and protein content decreased with the increasing plant population in both years, except for seed yield, harvest index and oil content. The highest seed yield was obtained from 510 000 plants ha^{-1} in 2002 and 2003 with 1633 and 1783 kg ha^{-1}, respectively.

Key words: Sesame, population density, planting method, Mediterranean

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an ancient oil crop supplying seeds for confectionary purposes, edible oil, paste, cake and flour. 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[1].

Yield of sesame is generally poor compared with other crops due to genetic and environmental factors[2]. Sesame is commonly grown in small-scale farms with less input and less mechanization in most of major sesame producing countries. Sesame yield could be improved by using better management practices and adapt to crop to the mechanical agricultural systems. Almost in most of the sesame planting areas of Turkey, broadcast planting is the only practiced cultivation because of the ease of broadcasting and lack of proper planting equipments. It is well known that broadcast planting always resulted in non-uniform plant spacing in the field. Uniform plant stands have mostly yield advantage over non-uniform plant spacing. Significant seed yield reduction due to non-uniform plant spacing were reported in several crop species such as sunflower[3], corn[4] and sorghum[5], but little is known about the effect of non-uniform plant population due to broadcast planting on sesame. Broadcast sowing also prevents mechanization during further management practices.

Optimizing of plant density is also very important for improving seed yield in a particular environment. The optimum plant density for sesame is influenced by several factors such as temperature, soil fertility, water availability and genotype. Hence, a width range of plant densities for the achievement of optimum yields in sesame can be found in literature[6-11]. However at the all of previous studies, different plant densities were obtained by manipulating inter- and intra-row spacing although sesame were sown as broadcast in many sesame production systems. There is little information on plant density and competition in broadcast sown sesame.

The objective of this study was to compare row and broadcast sowing and to determine optimum plant density for row and broadcast sown sesame under the Mediterranean conditions.

MATERIALS AND METHODS

The experiment was carried out in 2002 and 2003 at experimental fields of the Faculty of Agriculture, Mustafa Kemal University in Hatay, Turkey (36° 39’ N, 36° 40’ E). The soil of the experimental fields was loamy clay, low in organic matter and slightly alkaline. The climate is typical

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Mediterranean, with mild and rainy winter season and hot and dry summer season. Rainfall is concentrated between late autumn and spring. The mean temperatures during the experimental period ranged between 25°C (September) and 28.8°C (August) in 2002 and between 23.9°C (June) and 28.9°C (August) in 2003. The total rainfall during the experimental period was 16.0 mm in 2002 and 20.7 mm in 2003.

The experimental design was split plot with three replications. The two planting methods, row and broadcast, were allocated to the main plots and five plant density (102000, 127500, 170000, 255000 and 510000 plants ha^{-1}) to subplots. Each sub-plot was comprised of 14 m^2 area with 2.8 m wide and 5 m long. Sesame cultivar "Muganli 57" was sown on 24 and 20 June in 2002 and 2003, respectively. In the row planting plots, the rows were established with 0.7 m apart. The seeds were sown at high density to ensure adequate emergence and then, subplots were thinned to prescribed densities after one week from emergence. The crop was fertilized with 80 kg N ha^{-1} and 80 kg P_2O_5 ha^{-1} before planting and additional nitrogen dose at 80 kg ha^{-1} was applied at the beginning of flowering. Three surface irrigations were applied during growing period in both years. Two machine-hoeing in row planted plots and two hand-hoeing in broadcast planted plots were applied for weed control and soil aeration.

Plant height (cm), branch number per plant (branches/plant), capsule number per plant (capsules/plant), number of seeds per capsule (seeds/capsule) and capsule length (cm) were recorded on ten plants randomly chosen in each sub plot before harvesting. Plants were harvested when lower pods start to dry out and allowed to dry for around ten days before threshing. Biological yields of plots were recorded and after threshing seed yields, harvest indices and 1000-seed weight were determined. The oil contents of seeds were determined using the Soxhlet method and protein contents of seeds were determined using the Khejdal method.

Data were analyzed using standard analysis of variance (ANOVA) technique and means were separated using least significant difference comparisons.

RESULTS AND DISCUSSION

Haulm growth: The row planting of sesame gave taller plants in both years although the differences between planting methods were found as significant only in 2002. The higher number of branch per plant also obtained from row planting in both years (Table 1). The row planting caused more uniform distribution of plants in the field as well as allowed better cultivation and irrigation. Consequently, abundant plant growth occurred with row planting.

Plant height and number of branch per plant were significantly affected by plant population in both years (Table 1). The mean plant height was gradually shortened with increasing plant population. Generally, denser plant cultivations produce longer stems, due to the effects of the composition of the light that penetrates the plant canopy, while the larger spacing causes the development of vegetative lateral shoots[12]. Jadhav *et al.*[8] also reported that closer spacing increased plant height but reduced the number of branches per plant in sesame. In current study, sesame was grown with irrigation under high temperature and light intensity and probably none of the evaluated plant densities caused reduction on light interception. Hence, low plant population resulted in vigorous haulm growth due to less interplant competition for nutrients and water.

Capsule and seed number: The number of capsule per plant and number of seed per capsule were significantly affected by planting methods in both years (Table 1). Row planting of sesame resulted in higher number of capsule per plant and seed per capsule in both years. This result indicated that row planting is more favorable also for generative growth of sesame.

The population significantly affected both number of capsule per plant and number of seed per capsule in either year (Table 1). The highest number of capsule per plant and of seed per capsule were obtained from the lowest plant population (102 000 plants ha^{-1}) while the lowest values were obtained from the highest plant population (512 000 plants ha^{-1}) in both years. Plants grown at low populations received a higher red/far red light ratio compared with denser populations which caused a greater portion of total vegetative dry matter to be partitioned into branches[13]. Furthermore, inter-plant competition for nutriets and water reduced with decreasing plant population This, in turn, created greater number of capsule per plant and number of seed per capsule at the low populations. Similar findings with sesame were also reported by Jadhav *et al.*[8] and Majumdar and Roy[9].

1000-seed weight: No conspicuous difference in 1000-seed weight was found between planting methods although difference was considered as statistically significant in 2003 (Table 1). One thousand-seed weight gradually decreased from 3.7 g to 3.2 g with increasing of plant population in both years. Majumdar and Roy[9] reported insignificant reduction in 1000-seed weight with increasing of plant population.

Table 1: Effect of planting methods and plant population on yield and yield components of sesame

	Plant height (cm)		Branch number plant^{-1}		Capsule number plant^{-1}		Seed number capsule^{-1}		Seed weight (g)		Harvest index (%)		Seed yield kg ha^{-1}		Oil content (%)		Protein content (%)	
Treatments	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Planting method																		
Broadcasting	87.2	132.7	2.2	2.3	40.5	38.6	41.6	42.5	3.4	3.4	15.7	18.1	1023	1073	53.5	54.0	19.2	18.9
Row planting	99.3	139.9	2.7	2.9	43.0	47.2	50.4	47.1	3.6	3.5	16.6	19.2	1365	1443	53.8	54.1	19.0	19.5
LSD (P=0.05)	1.6	n.s.	0.4	0.6	1.7	1.3	2.3	4.7	n.s.	0.02	n.s.	0.5	224	132	0.4	n.s.	n.s	1.1
Plant population ha^{-1}																		
102 000	99.2	142.0	2.8	3.4	49.5	49.0	53.6	53.0	3.7	3.7	14.2	17.3	901	956	54.1	54.8	18.4	18.7
127 500	95.2	138.3	2.6	2.8	46.5	46.4	52.4	49.5	3.6	3.5	14.7	17.8	960	1004	53.9	54.4	18.6	18.9
170 000	93.0	136.5	2.3	2.6	44.6	44.4	46.2	44.9	3.5	3.4	16.2	18.3	1155	1103	53.7	54.0	19.1	19.2
255 000	91.1	132.9	2.4	2.3	37.8	41.5	41.1	42.4	3.4	3.3	17.3	19.4	1321	1445	53.5	53.7	19.4	19.5
510 000	87.8	131.8	2.1	1.9	30.1	33.3	34.7	34.3	3.2	3.2	18.4	20.5	1633	1783	53.0	53.5	19.8	19.9
LSD (P=0.05)	1.9	5.3	0.2	0.6	1.2	1.3	1.5	1.1	0.1	0.06	0.4	0.9	54	63	0.6	0.5	0.6	0.3
Planting method	**	n.s.	**	*	**	**	**	*	n.s.	*	n.s.	**	**	**	*	n.s.	n.s.	*
Plant population	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*	n.s.	**	**
P. met. x P. pop.	**	n.s.	n.s.	n.s.	n.s	**	**	**	**	**	**	n.s.	**	**	n.s.	**	n.s.	n.s.

n.s.= not significant, *, ** indicate significant at P = 0.05 and 0.01 probability level, respectively

Harvest index: The harvest index slightly increased with row planting in both years, but the effect of planting methods on harvest index was found as significant only in 2003 (Table 1). Harvest index of sesame plants was significantly affected by plant population in both years. The mean harvest index values increased from 14.2 to 18.4% in 2002 and from 17.3 to 20.5% in 2003 with increasing of plant population from 102 000 to 510 000 plants ha^{-1}. The low plant populations resulted in abundant vegetative growth with taller and more branched plants due to reducing inter-plant competition. Hence, harvest index of these plants reduced. Similarly Majumdar and Roy[9] found greater harvest index with higher plant populations.

Seed yield: The seed yield of sesame crop was significantly affected by planting methods and plant populations in both years (Table 1). The row planting resulted in around 34% higher seed yield comparing to broadcast planting in both years. This could be attributed the spatial distribution of the plants in the field with row planting. At row planting method, the distance among plants was more uniform, therefore, each plant had enough space for light interception, whereas, at broadcast planting, the distance between two plants may be very close or very far due to uneven distribution of the plants. Thus, some of the plants had extra space to intercept light and absorb moisture and nutrition while others suffer for those required growth factors, therefore, phenotypic appearance of the plants were highly variable at broadcast planting. Similarly, significant seed yield reduction due to non-uniform plant spacing was reported in several crop species such as sunflower[3], corn[4] and sorghum[5].

Seed yield significantly varied among plant populations in both years (Table 1). The highest seed yields were obtained from 510 000 plant ha^{-1} with 1633 and 1783 kg ha^{-1} in 2002 and 2003, respectively. Seed yield gradually decreased with the decreasing plant population. Seed yield decrease due to decreases in population from 510 000 to 102 000 plants ha^{-1} was 45 and 46% in 2002 and 2003, respectively. Increasing plant population caused a reduction around in number of capsule and seed per plant and consequently yields of individual plant. However increase rate in number of plant per unit area was much greater than decrease rate of yield components of individual plants. Hence higher plant population lead to higher seed yields per unit area. Similarly, the reduction in yield caused by low population density in soybean were attributed to lower pod and seed number per unit area by Ball *et al.*[14] and Gan *et al.*[15]. Ball *et al.*[14] further concluded that seed number per unit area was directly proportional to the ratio of crop growth rate, high population ensured early canopy coverage and maximized light interception, greater crop growth rate and crop biomass, resulting in increased seed number and yield potential. The sesame crop probably gave similar response to population density in current study. Similar yield reduction with the decreasing plant population in sesame was also reported by Chimanshette and Dhoble[6], Dilip *et al.*[7] and Majumdar and Roy[9].

Seed quality: The effects of planting methods on oil and protein content of seeds were little in both years (Table 1). The oil content of seeds was slightly decreased with increasing plant population while the differences were found as significant only in 2002. In contrast to oil content, the protein content of seeds was significantly increased with increasing population density in both years.

As a result of this two-year field study, it was concluded that growth and yield of sesame crop increased with row planting due to more uniform distribution of plant in the field. Row planting also allowed better cultivation during crop growth. The population density also significantly affected to all growth and yield parameters. Increasing plants population reduced yield components and yield of individual plants but increased yield per unit of area. Therefore row planting of sesame with high density (510 000 plants ha^{-1}) could be suggested for high seed yield in double crop sesame production under irrigated Mediterranean type environments.

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