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Influence of Irrigation Intervals and Row Spacing on Some Yield Components of Sesame Grown in Harran Region

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Abstract: The objective of this study was to determine the effects of irrigation intervals and row spacing on yield, plant height, number of branches and number of capsules in sesame for 2 years period. Four irrigation intervals (6, 12, 18 and 24 day intervals) and four row spacings (50-30, 70-30, 80-40 and 70-70 cm) with three replications were applied in the study of Harran plain conditions which characterized as semi-arid area in Turkey. Decreasing row spacing increased the yield per hectare, but decreased capsule number per plant. The highest yields were obtained at 50-30 cm row spacing with 6 and 12 day interval combination (179.0 and 180.5 kg ha^{-1}, respectively), while the lowest yields were obtained at the 70-70 cm row spacing (59.9 kg ha^{-1}) at 24 day interval combination. Generally, the higher yields were obtained from narrow row spacing and short irrigation intervals. For short-season production systems, narrow row spacing ensured early canopy coverage and maximized light interception, crop growth rate on crop biomass, resulting in the increased pod number and yield potential per unit area.

Key words: Row spacing, irrigation intervals, sesame, yield

INTRODUCTION

Sesame is an important agricultural crop which has been cultivated since ancient times. As sesame seeds contain 50-60% of vegetable oil and 20-30% of protein, it is a significant crop of agrarian-industrial importance. Cultivation of sesame in special large scales is fixed especially in the Southeastern, Mediterranean and Aegean areas of the Turkey. Due to short period of maturation, relatively low production costs and possibility that can be cultivated with other crops (Atakişi, 1984). In Turkey, about 68, 000 ha of cultivated area are under sesame cultivation and it is informed that about 60% of the total sesame produced in the country is crown in the Southeastern Anatolia (Anonymous, 1998).

In order to reach high crop capacity index in agricultural activity the correct choice of irrigation method is of great importance. Naturally, cultivation of plants is impossible without water. For normal vegetation and maturation of plants the availability and preservation of sufficient humidity level in soil during the whole plant maturation period are required. At normal conditions, the humidity level of soil required for plants is ensured, however, in conditions of dry and non-rainy areas it is necessary to apply sprinkle irrigation. The water consumption indexes are influenced by such factors as duration of vegetation period, climate conditions (temperature, precipitations, humidity, evaporation and wind speed), level of soil humidity, topographical conditions, soil structure and etc. (Delibaş, 1994).

At increasing of sowing density up to definite mark increasing of crop capacity and the area along with decreasing of the number of capsules and branches on the plant per area unit was fixed (Torres-Osejo and Velasquez-Silva, 1986, 1987), Avila *et al.* (1992) and Cannabasavanna and Setti (1992). Research conducted in Sudan, a significant growth of crop capacity, plant length and number of capsules on the plant was marked dependent on increasing the distance between sowings along the seedbed (Osman, 1993).

Sesame in comparison with other seeds of oil plants has a great quantity of oil and oil percentage varied between 37 and 63%. Gercek *et al.* (2004) in the researches conducted in Salyurt in order to determine effect of irrigation methods and the distance between seedbeds on population of local sesame in the second production sowing conditions established the fact of variation of plant length between 105 and 108 cm, number of branches 4.06-4.75 per plant, number of capsules 89-108 per plant.

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The variability in cultural practices such as irrigation types and intervals, sowing intervals, variety properties etc. (Avila *et al*., 1992; Majumdar and Roy, 1992) are important abiotic factors affecting sesame yield. Miscellaneous fungal disease infecting on root, stem root, stem and foliar components are other important biotic factors that cause yield losses on sesame production (Abd-El-Ghany *et al*., 1974; Pramod *et al*., 1992; Dinakaran *et al*., 1994; Bahkali and Moslem, 1996).

The amount of water uptake including evaporation from the soil and transpiration from the plant is under the strong influence of environmental conditions. The transpiration from the plant tissues depends on canopy size, wind and water potential and other leaf characteristics that offer for resistance around the plant root. Thus, if the plants are planted wide apart, the soil surface per unit area is high and, in contrast, if the plants are planted with high density, the leaf area index per unit area is higher normally.

It is possible to provide plant's water requirement by adjusting the plant density. The water use efficiency and rate affected by row spacing are the main factors for sesame production especially in relatively arid regions (Wilcox, 1987).

Majumdar and Roy (1992) reported that irrigation in sesame caused an increase in yield and there was no significant difference between 30 and 40 cm row spacings. With the increase in plant density in sesame, the leaf area index and dry matter contents are affected positively (Ghosh and Patra, 1993; Behera *et al*., 1994); the plant height, first capsule height, number of capsules and capsule height are not influenced significantly (Ghosh and Patra, 1993); number of capsules (Torres-Osejo and Velasques-Silva, 1986, 1987) and the number of branches (Ghosh and Patra, 1993) decline and finally, the seed yield increases (Ghosh and Patra, 1993; Behera *et al*., 1994; Avila *et al*., 1992; Torres and Velasques-Silva, 1987).

It has been reported that the yield of sesame increased with the decrease in row spacing. Tiwari *et al.* (1994) found that the average yields of four sesame varieties planted as 30×15 and 10×10 cm spacings were 2.05 and 3.00 t ha^{-1}, respectively. Mandal *et al.* (1990) investigated the relationship between plant density and the yield of B-67 sesame variety and reported that increase in plant density from 110 000 plants per hectare to 166 000 and 222 000 plants per hectare resulted in 0.77, 0.89 and 1.08 ton ha^{-1}, yield increases, respectively.

MATERIALS AND METHODS

In this study, a local dark sesame was grown in June of 1998 and 1999 in the Faculty of Agriculture, Department of Field Crops, Harran University, Turkey. The experimental design for irrigation methods and row space trials was a randomized complete block design of split-plot with three replications. The research field is located in an arid climate where the summer is hot and dry and the winter is cool and dry. The altitude of the research field is 467 m. The field is located at 37°-08 N and 38°-46 E. Trials were conducted on a silted-clay soil (Bouyoucus, 1952) at pH 7.5 (Grewelling and Peech, 1960) and lime content was 99000 ppm (Caglar, 1984) without salinity problem 620 ppm (Peech, 1965) which was deficient in organic matter 11200 ppm (Hizalan, 1963). Modify potassium was 780 kg ha^{-1} (Jakson, 1962).

Field capacity was between 32.71 and 33.19%, permenant wilting point was 21.18 and 22.55% and bulk density of experiment soils were changed. Irrigation water was determinated in C_2S_1 soil classification. Soil moisture between 0-30 cm layer was determinated by gravimetric method. Sprinkle irrigation was applied and 12 sprinkles were laid down in 6×6 m interval as square for per sprinkle irrigation plot. The meteorological data recorded from planting date to the harvest of each treatment are given in Table 1.

All treatments were fertilized with 100 kg ha^{-1} nitrogen (50% after planting) and 60 kg ha^{-1} phosphorus in each year. Seeds were planted with 20 cm in 4 m rows. Germination percentage of seed was 100%. The four row spacings were alternating rows of 50-30, 70-30, 80-40 cm in 6 row-plots and 70-70 cm in 4 row-plots.

50-30-50-30-50-30 cm	= 12.5 seeds m^{-2} or 125,000 seeds ha^{-1}
70-30-70-30-70-30 cm	= 10.0 seeds m^{-2} or 100,000 seeds ha^{-1}
80-40-80-40-80-40 cm	= 8.33 seeds m^{-2} or 83,300 seeds ha^{-1}
70-70-70-70 cm	= 7.13 seeds m^{-2} or 71,300 seeds ha^{-1}

Planting and harvesting dates are in Table 2. Twenty plants per plot were randomly sampled to determine capsules number, branches number and plant height at harvest. Plant height was calculated with measurement between soil surface and top of plants. To determine seed yield, plants were harvested from middle two rows of six rows per plot treatment. Harvest was done by hand.

The area of experimental plot for each row space was:

For 50 cm-30 cm row space: 2.5 m×4 m
For 70 cm-30 cm row space: 3.0 m×4 m
For 80 cm-40 cm row space: 3.6 m×4 m
For 70 cm-70 cm row space: 2.8 m×4 m

The total prowing area for each plot was calculated as 47.2 m^2.

Water was applied to keep the soil at 0-90 cm field capacity in the first irrigation. The amount of required irrigation water was calculated by Class A evaporation

Table 1: Monthly mean temperatures and rainfall during the growing season for sesame (June-October) in 1998 and 1999

	Mean temp. (°C)		Minimum temp. (°C)		Maximum temp. (°C)		Total rainfall (mm)	
Month	1998	1999	1998	1999	1998	1999	1998	1999
June	29.4	28.8	17.8	18.8	41.2	40.0	0.6	1.6
July	33.0	32.5	19.8	21.5	45.4	43.2	nr	nr
August	33.4	31.2	22.6	20.5	43.0	43.0	nr	26.0
September	27.0	26.2	15.1	17.0	39.6	36.6	0.0	nr
October	21.5	21.0	10.2	11.3	34.1	35.6	0.1	8.4

* nr. no rainfall

Table 2: Planting and harvesting dates for the different row spacings for sesame in 1998 and 1999

Row spacings (cm)	Harvest dates 1998(*)	Row spacings (mm)	Harvest dates 1999(**)
50-30	10 November	50-30 mm	13 November
70-30	05 November	70-30 mm	07 November
80-40	01 November	80-40 mm	03 November
70-70	25 October	70 mm	28 October

*: Planted June 15, 1998, **: Planted June 19, 1999

pan every day (Kanber, 1984). Experiment was irrigated at 12 days interval. Total water level, measured by using a manual limnimeter with 0.1 mm accuracy, was multiplied by area to calculate volume of water evaporated. These measurements were checked with the readings obtained from flow meters mounted in each plot.

$$\text{Eq. } ET = P + I\text{-}R\text{-}D_p \pm \Delta S$$

Where; ET is crop water consumption, P is rainfall, I is irrigation water, R surface flow, Dp is deep percolation, dS soil water content variation in crop root depth.

Since high sprinkle irrigation rate causes soil and water losses, a 80% of accumulated evaporation was applied based on soil infiltration rate. Water was supplied from a well located in the experimental area. The space between the in-line type of drippers was 33 cm and flow rate of 2.5 L h^{-1} for 1 atmosphere. The lateral with a 16 mm diameter was placed in the centre of two rows.

Statistical analysis was carried out using Statistical Analysis programme (TARIST, version 1) (Açikgöz *et al*., 1993) using general linear model (GLM). Significant differences were determined using LSD (Least Significant Diffrence) multiple range test at $p<0.05$.

RESULTS AND DISCUSSION

Total applied water between 1998 and 1999 growing seasons was 971 and 1037 mm while evapotranspration rate of the sesame was 995 and 1111 mm (sprinkle), respectively. There was a similar trend for applied water and water use of sesame in both years. Since precipitation was higher in 1998 compared to 1999, soil moisture storage was higher in 1998 according to soil moisture in 1999. These results are in agreement with the findings of Sepaskhah and Andam (2001).

Variation of seed yield was highly significant for the irrigation intervals, row spacing and irrigation intervals x row spacing interactions $p<0.001$. But, variation of plant height was only significant for the irrigation interval at ($p<0.0001$) and not significant for row spacing and irrigation intervals×row spacing interaction effects. Variation of branch number was significant for the irrigation intervals and row spacing at ($p<0.01$) and not significant for irrigation intervals x row spacing interaction effects. Variation of capsule number was highly significant for irrigation intervals at ($p<0.001$) and was significant for row spacing at ($p<0.05$) and was significant for irrigation intervals×row spacing interaction effects at ($p<0.001$) (Table 3).

According to the two years results, it was noted that the highest plant height (136.0 cm) was obtained at 70-30 cm row spacing in 6 day irrigation intervals while the lowest plant height was obtained at 70-70 cm row spacing and 24 day irrigation intervals. The highest branch number (4.80 per plant) was obtained at 70-70 cm row spacing and 12 day irrigation intervals and the lowest branches number (3.08 per plant) was obtained at 70-30 cm row spacing at 24 day irrigation intervals (Table 4).

The highest seed yield (180.5 kg ha^{-1}) was obtained from 50-30 cm row spacing at 12 day irrigation intervals while the lowest seed yield (59.9 kg ha^{-1}) was obtained from 70-70 cm row spacing at 24 day irrigation intervals. The highest capsule number (112.3 per plant) was obtained from 70-70 cm row spacing at 6 day irrigation intervals and the lowest capsule number (55.4 per plant) was obtained from 70-70 cm row spacing at 24 day irrigation intervals. Generally, the results indicated that 6 and 12 day irrigation intervals and narrow row spacing provided better results than 18 and 24 day irrigation intervals and broad row spacing. In narrow row spacing and irrigation intervals the plants were able to uptake more nutrient and water.

Table 3: ANNOVA results for plant height, brunch number, capsula number and seed yield and agronomic factors

Source of variation	df	Plant height	Branch number	Capsule number	Seed yield
Replication	2	0.288	0.421	87.74	72.183
Irrigation Intervals	3	6183.44***	4.32**	6093.34***	12968.81***
Error 1	6	22.89	0.249	92.598	22.660
Row Spacing	3	5.051	1.72**	287.20*	6838.76***
Irrigation Interval*Row Spacing	9	52.06	0.59	284.29**	284.55***
Error 2	24	38.87	0.330	86.177	37.657
Error	47	427.76	0.718	521.267	1343.996

*: Significant at $p<0.05$., **: Significant at $p<0.001$, ***: Significant at $p<0.0001$

Table 4: Average plant height, branch number, seed yield and capsule number of sesame grown at different row spacing and irrigation intervals

	Plant height (cm)			
Row spacing	6 days interval	12 days interval	18 days interval	24 days interval
50-30 cm	126.0b	112.3a	108.9a	95.6a
70-30 cm	136.0a	111.2a	98.2b	87.8b
80-40 cm	120.2b	113.9a	93.6b	89.5ab
70-70 cm	122.8b	112.1a	95.6b	84.5b
LSD (5%)			6.80	
Branches number (per plant)				
50-30 cm	3.83a	3.77b	4.27ab	3.55a
70-30 cm	3.93a	4.57a	4.12b	3.08a
80-40 cm	4.33a	4.40a	4.25ab	3.40a
70-70 cm	4.13a	4.80a	4.78a	3.45a
LSD (5%)			0.60	
Seed yield (kg ha^{-1})				
50-30 cm	179.0a	180.5a	155.5a	113.2a
70-30 cm	170.9b	153.4b	136.1b	78.6b
80-40 cm	128.3c	126.6c	128.7c	64.1c
70-70 cm	120.8d	115.3d	115.3d	59.9c
LSD (5%)			6.09	
Capsule number (per plant)				
50-30 cm	83.7c	77.5b	85.5b	74.3a
70-30 cm	95.1b	80.2b	75.2c	65.7ab
80-40 cm	105.3a	92.8a	84.8bc	56.6bc
70-70 cm	112.3a	96.1a	95.9a	55.4c
LSD (5%)			9.98	

Similar results for the characters being studied in this experiment, were reported in other studies of Yazar *et al.* (1991), Glenn *et al.* (2000), Paltineanu *et al.* (1994), Graterol *et al.* (1996), Vearela (1998), Vpraveen and Raikhelkar (1994) in soybean and sesame.

CONCLUSIONS

Results showed that the highest seed yields were obtained from 6 and 12 day irrigation intervals while the lowest seed yield was obtained from 24 day irrigation interval. Overall, the yield of seed decreased with the increase in irrigation intervals. This probably resulted from the fact that the increase of evaporation in a defined area caused decrease in the seed yield. In addition, long irrigation intervals caused water loss by evaporation. As a results of this study, the highest yield in sesame can be obtained when the crop was irrigated intervals as narrow as possible up to 6 days interval.

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