

Full Length Research Paper

Seed yield and some yield components of sesame as affected by irrigation interval and different levels of N fertilization and superabsorbent

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In order to study the effect of different irrigation, N and superabsorbent levels on yield and yield components of sesame, a field experiment was conducted in Khosf Region, Birjand, Iran in 2009 as a split-split plot design based on a randomized complete block design. The treatments included irrigation interval at three levels of six, 12 and 18 days as main plot, N fertilization level at three levels of 0, 100 and 200 kg.ha⁻¹ as sub-plot and superabsorbent level at two levels of 0 and 200 kg.ha⁻¹ as sub-sub-plot. Results of analysis of variance showed that irrigation interval and N fertilization levels significantly affected seed yield, single-plant biomass yield, straw yield, seed yield per capsule and seed yield per plant, but their effect on seed harvest index was not significant. Means comparison revealed that as irrigation interval was increased from six to 18 days, seed yield, single-plant biomass yield, straw yield, seed yield per capsule and seed yield per plant were significantly decreased by 44.5, 54.2, 44.31, 35 and 54.4%, respectively. Also, the increase in N fertilization level from 0 to 200 kg.ha⁻¹ decreased them by 25.6, 16.7, 16.2, 18.8 and 28.8%, respectively. In total, according to the results, six days irrigation interval fertilized with 200 kg N.ha⁻¹ is recommended for the cultivation of sesame in Birjand, Iran.

Key words: Sesame, irrigation, nitrogen, superabsorbent, seed yield.

INTRODUCTION

The application of oilseeds in feeding people and its meal in feeding animals as well as its application in pharmaceuticals, fuel and soap industries has aroused farmers' interest in its cultivation (Weiss, 1971). Sesame is known as one of the most important edible seeds in traditional farming in hot and semi-hot regions and is apparently the earliest oilseed to come to cultivation by human being. Kim et al. (2007) showed that drought stress significantly decreased seed yield per plant in sesame but it did not influence its seed weight per plant. Fredrick et al. (2001) revealed that water deficit significantly affected the yield of auxiliary branches in soybean, so that its yield was higher under normal conditions than under stress. Bahrani and Babaei (2007) observed that as N fertilization level was increased, seed

yield increased, so that the highest seed yield was obtained from N fertilization level of 90 kg.ha⁻¹. The application of some amendments like superabsorbent polymers maximizes yield potential by mitigating water-deficit stress, improving nutrients availability and providing appropriate conditions in soil.

Kashi and Asgarzadeh (2005) stated that superabsorbent were highly capable of absorbing water. They could maintain water for a long time and could absorb water more than their initial volume of which, this water is gradually delivered to the plants. Yazdani et al. (2007) reported that seed yield of soybean was influenced by different levels of superabsorbent, so that higher levels of superabsorbent application resulted in higher seed yield. Also, they found that the application of superabsorbent polymer could increase the yield of soybean under drought stress as well as under well-irrigated conditions. Therefore, the current study was carried out to study the effect of different levels of N fertilization and

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Table 1. Results of analysis of variance for the effect of different levels of irrigation interval, N fertilization and superabsorbent on seed yield and yield components of sesame.

S.O.V.	df	Seed yield (kg.ha ⁻¹)	Seed yield/plant (g)	Seed yield/capsule (g)	Single-plant biomass yield (g)	Straw yield (kg.ha ⁻¹)	Seed harvest index/capsule (%)
Replication	2	1627.230 ^{ns}	9.852 ^{ns}	0.007 ^{ns}	609.500 ^{ns}	9985.463 ^{**}	32.396 ^{ns}
Irrigation	2	422069.600 ^{**}	169.844 ^{**}	0.031 [*]	10823.24 ^{**}	20307978.999 ^{**}	51.029 ^{ns}
Error 1	4	1580.076	4.194	0.004	503.387	862.513	62.735
N	2	66687.245 ^{**}	19.716 ^{**}	0.004 [*]	485.268 ^{**}	1448856.412 ^{**}	111.732 ^{ns}
Irrigation × N	4	6087.107 ^{**}	0.642 ^{ns}	0.003 [*]	76.453 ^{ns}	40919.320 ^{**}	6.914 ^{ns}
Error 2	12	320.073	0.776	0.001	44.977	1084.031	76.528
Superabsorbent	1	825.331 ^{ns}	0.925 ^{ns}	0.000 ^{ns}	37.101 ^{ns}	15561.125 ^{ns}	80.037 ^{ns}
Irrigation × superabsorbent	2	415.523 ^{ns}	0.076 ^{ns}	0.000 ^{ns}	2.664 ^{ns}	4212.954 ^{ns}	191.083 ^{ns}
N × superabsorbent	2	29.721 ^{ns}	0.709 ^{ns}	0.001 ^{ns}	2.821 ^{ns}	6637.359 ^{ns}	20.580 ^{ns}
Irrigation × N × superabsorbent	4	180.613 ^{ns}	0.689 ^{ns}	0.001 ^{ns}	48.913 ^{ns}	8299.022 ^{ns}	9.719 ^{ns}
Error 3	18	301.783	0.453	0.001	50.926	5438.444	72.610
Coefficient of variations (%)		3.28	8.10	17.53	10.57	1.95	16.23

superabsorbent polymers at different irrigation intervals on seed yield and some yield components of sesame.

MATERIALS AND METHODS

The study was carried out in Khosf Region, Iran (Long. 59°13' E., Lat. 32°53' N., Alt. 1480 m) in 2009 as a split-split plot based on a randomized complete block design with three replications. Irrigation interval was the main plot at three levels of six, 12 and 18 days. N fertilizer was the sub-plot at three levels of 0, 100 and 200 kg.ha⁻¹ and superabsorbent was the sub-sub-plot at two levels of 0 and 200 kg.ha⁻¹. The seeds of a local accession were used. The plots were 6 m long of which included six rows with 45 cm within-row spacing and 5 cm within-plant spacing. The soil of the field was clay-sandy with organic matter content of 0.11%, electric conductivity of 8.42 ds.m⁻¹ and pH of saturated soil of 8.09. The soil preparation operations including plowing, disking and leveling were carried out in May 2009. The seeds were manually planted at the depth of 1.5 to 2.5 cm in June 20. To avoid soil-borne seed diseases, the seeds were disinfected by Benomyl 2:1000

before sowing. The weeds were manually controlled during growing season. The plants were thinned at six-leaf stage and at the same time, irrigation treatments were applied. Also, N fertilizer (from urea source) was applied at three stages including after thinning, early-flowering and late-flowering stages. The superabsorbent polymer Tarawat A200 (manufactured in Iran Polymer and Petrochemical Institute) was used in a strap form at two levels of 0 and 200 kg.ha⁻¹.

They were applied at the depth of 20 to 25 cm at the middle of wide ridges before sowing. Before harvesting, 10 plants were selected from the two middle rows in each plot and then, their single-plant biomass yield, seed yield per capsule, seed yield per plant and seed harvest index per capsule was measured. When the plants in the two middle rows of the plots were yellowish but their capsules have not cracked yet, they were harvested on November 5, then dried by fresh air.

Afterwards, their capsules were cut and their seed yield (with 10% moisture) was measured. Capsule shell and plant residues were put in an oven at 75°C for 72 h and were weighed after getting dried. Finally, straw yield was measured. At the end, the data were statistically analyzed by software MS-TATC and the means were compared by Duncan test at 5% level.

RESULTS AND DISCUSSION

Seed yield

Results of analysis of variance showed that irrigation interval, N fertilization level and their interaction significantly impacted seed yield at 1% probability level, but the influence of superabsorbent application and other interactions was not significant on seed yield (Table 1). The highest seed yield (on average, 687.04 kg.ha⁻¹) was obtained from six days irrigation interval which was 32 and 80.2% higher than that obtained from 12 and 18 days irrigation intervals, respectively (Table 2). This was related to the decreased competition between plants and the increased number of auxiliary branches and capsules per plant. These results are in agreement with the results obtained by Rezvani Moghaddam et al. (2005) and Praksh and Thimmegoawd (1991) about sesame.

Table 2. Means comparison for the effects of irrigation interval, N and superabsorbent on seed yield and yield components of sesame.

Treatment	Seed yield (kg.ha ⁻¹)	Seed harvest index/capsule (%)	Straw yield (kg.ha ⁻¹)	Single-plant biomass yield (g)	Seed yield/capsule (g)	Seed yield/plant (g)
Irrigation interval (day)						
6	687.04 ^a	52.15 ^a	4680.87 ^a	88.42 ^a	0.20 ^a	11.29 ^a
12	520.68 ^b	51.03 ^a	40132.10 ^b	73.58 ^a	0.21 ^a	8.49 ^b
18	381.17 ^c	54.34 ^a	2604.63 ^c	40.52 ^b	0.13 ^b	5.15 ^c
N (kg.ha⁻¹)						
0	462.35 ^c	54.92 ^a	3468.52 ^c	62.31 ^c	0.16 ^b	7.26 ^c
100	545.68 ^b	52.65 ^a	3818.83 ^b	67.52 ^b	0.18 ^{ab}	8.31 ^b
200	580.86 ^a	49.94 ^a	4030.25 ^a	72.69 ^a	0.19 ^a	9.35 ^a
Superabsorbent (kg.ha⁻¹)						
0	525.72 ^a	51.29 ^a	3755.56 ^a	66.68 ^a	0.18 ^a	8.18 ^a
200	533.54 ^a	53.72 ^a	3789.51 ^a	68.34 ^a	0.18 ^a	8.44 ^a

Means of traits in each column with similar letter(s) were significant at 5% level.

Table 3. Means comparison for the interaction between irrigation interval and N.

Irrigation interval (day)	N level (kg.ha ⁻¹)	Seed yield (kg.ha ⁻¹)	Seed yield/capsule (g)	Straw yield (kg.ha ⁻¹)
6	0	587.04 ^c	0.20 ^{abc}	4425.93 ^c
	100	703.70 ^b	0.20 ^{abc}	4660.19 ^b
	200	770.37 ^a	0.19 ^{abc}	4956.48 ^a
12	0	452.78 ^e	0.18 ^{bc}	3766.67 ^f
	100	541.67 ^d	0.21 ^{ab}	4113.89 ^e
	200	567.59 ^{cd}	0.25 ^a	4215.74 ^d
18	0	347.22 ^g	0.11 ^d	2212.96 ⁱ
	100	391.67 ^f	0.15 ^{cd}	2682.41 ^h
	200	404.63 ^f	0.14 ^{cd}	2918.52 ^g

Means with similar letter(s) in each column were not significant at 5% probability level on the basis of Duncan test.

Means comparison for seed yield at different N fertilization levels indicated that the application of 200 kg N.ha⁻¹ gave rise to 6.5 and 25.6% higher seed yield than the application of 100 and 0 kg N.ha⁻¹, respectively (Table 2). Also, Papari Moghaddam Fard and Bahrani (2005) observed significant increase in seed yield with the increase in N application.

Although the increase in N application had a positive effect on seed yield at all irrigation levels, this effect was much greater and significant at optimum irrigation level, so that the highest seed yield (on average, 770.37 kg.ha⁻¹) was obtained from six days irrigation interval along with the application of 200 kg N.ha⁻¹ which was 31.2% higher than that obtained from six days irrigation interval without N fertilization (Table 3). The increase in water and N

availability paves the way for the vegetative growth of the plants and increases plant photosynthesizing area, assimilation, the number of capsules per plant and the number of seeds per capsule which finally, results in the significant increase in seed yield. Seed yield significantly and positively correlated to seed yield per plant, seed yield per capsule, single-plant biomass yield and straw yield at 1% level (Table 4). This reveals that the trend of the variations of seed yield was similar to that of these traits.

Seed yield per plant

Irrigation interval and N fertilization level significantly

Table 4. Coefficients of correlation of the traits between yield and its components.

Trait	1	2	3	4	5	6
1. Seed yield (kg.ha ⁻¹)	1					
2. Seed yield/plant (g)	0.913**	1				
3. Seed yield/capsule (g)	0.489**	0.684**	1			
4. Single-plant biomass yield (g)	0.827**	0.958**	0.745**	1		
5. Straw yield (kg.ha ⁻¹)	0.933**	0.910**	0.607**	0.903**	1	
6. Seed harvest index/capsule (%)	-0.184	-0.107	-0.403**	-0.085	-0.190	1

**Significance at 1% level.

affected seed yield per plant at 1% statistical level, but this trait was not significantly affected by superabsorbent level and the interactions (Table 1). The highest seed yield per plant (on average, 11.29 g) was produced by six days irrigation interval and the increase in irrigation interval from six to 18 days decreased it by 54.4% (Table 2). It is likely that water deficit stress at seed setting stage resulted in the abortion in some capsules, their shedding and the decrease in seed weight per plant.

The increase in N fertilization level had a positive effect on seed yield per plant, so that the highest seed yield per plant (on average, 9.35 g) was obtained from N fertilization level of 200 kg.ha⁻¹ which was 12.5 and 28.8% higher than N fertilization levels of 100 and 0 kg.ha⁻¹, respectively (Table 2). Probably, the increase in N fertilization induced vegetative growth and increased the number of auxiliary branches in sesame through which it increased the number of flowers and capsules per plant and so, it resulted in higher seed yield per plant.

Seed yield per capsule

According to the results of analysis of variance, irrigation interval, N fertilization and their interaction significantly impacted seed yield per capsule at 5% statistical level, but superabsorbent application and other interactions did not significantly influence it (Table 1).

The highest seed yield per capsule (on average, 0.21 g) was produced under 12 days irrigation interval and the increase in irrigation interval from 12 to 18 days resulted in 38.1% lower seed yield per capsule (Table 2). It is probable that the increase in irrigation interval from 12 to 18 days decreased seed yield per capsule through reducing the uptake of water and nutrients, leaf photosynthesis and assimilation and as a result, increased the vulnerability of seed setting in capsules.

The increase in N fertilization level positively affected seed yield per capsule, so that the highest seed yield per capsule was obtained from N level of 200 kg.ha⁻¹ which was 5.6 and 18.8% higher than N levels of 100 and 0 kg.ha⁻¹, respectively (Table 2). Higher leaf area and plants' photosynthesis potential under higher N fertilization level can be regarded as the main reasons for

higher seed yield per capsule. Means comparison revealed that the treatment of the 12 days irrigation interval fertilized with 200 kg N.ha⁻¹ produced the highest seed yield per capsule (on average, 0.25 g) and the treatment of 18 days irrigation interval without N fertilization produced the lowest one (on average, 0.11 g) (Table 3).

Single-plant biomass yield

Irrigation intervals and N fertilization levels significantly affected single-plant biomass yield at 1% statistical level, but it was not significantly affected by superabsorbent and the interactions (Table 1). As irrigation interval was increased from six to 18 days, single-plant biomass yield decreased 54.2% from 88.42 to 40.52 g (Table 2) which can be related to the increase in vegetative growth, photosynthesizing potential and seed production potential at six days irrigation interval. These results are consistent with the results of Rezvani Moghaddam et al. (2005) and Dilip et al. (1991) on sesame.

As means comparison showed, the highest single-plant biomass yield (on average, 72.69 g) was obtained from N fertilization level of 200 kg.ha⁻¹ which was 7.7 and 16.7% higher than N fertilization levels of 100 and 0 kg.ha⁻¹, respectively (Table 2). N fertilization can increase single-plant biomass yield by improving vegetative growth and leaf area development and duration.

Straw yield

According to the results of analysis of variance, the effect of irrigation interval, N fertilization level and their interactions was significant on straw yield at 1% statistical level, but superabsorbent application and other interactions did not impact this trait significantly (Table 1).

The increase in irrigation interval decreased straw yield, so that the highest straw yield (on average, 4680.87 kg.ha⁻¹) was obtained from six days irrigation interval which was 16.1 and 79.7% higher than 12 and 18 days irrigation intervals, respectively (Table 2). It can be related to the decrease in photosynthesizing potential

and vegetative growth of sesame under water deficit stress.

As indicated by means comparison, the application of 200 kg N.ha⁻¹ resulted in the highest straw yield (on average, 4030.25 kg.ha⁻¹) which was 5.5 and 16.2% higher than straw yield obtained from the application of 100 and 0 kg N.ha⁻¹, respectively (Table 2). N fertilization can increase straw yield in sesame by improving vegetative growth and the number of branches.

Means comparison for the interaction between irrigation interval and N fertilization revealed that the increase in N fertilization level significantly increased straw yield only when adequate moisture was provided for the plants, so that the treatment of six days irrigation interval fertilized with 200 kg N.ha⁻¹ produced the highest straw yield (4956.48 kg.ha⁻¹) which was 12% higher than that produced by the treatment of six days irrigation interval without N fertilization (Table 3). Seemingly, the effect of N fertilization vanishes under water deficit conditions due to the loss of its uptake (Jonse, 1984).

Seed harvest index per capsule

Seed harvest index per capsule was affected by none of the simple effects and interactions (Table 1).

Conclusion

In total, on the basis of the results of the current study, it can be concluded that providing adequate moisture and N can increase seed yield of sesame by significantly increasing most of its yield components and so, it is recommended to use the treatment of six days irrigation interval fertilized with 200 kg N.ha⁻¹ to obtain a high economical yield of sesame. Also, it should be noted that the application of superabsorbent exactly under the sowing rows of sesame might have positive effect on its vegetative and reproductive growth and yield which needs further study.

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