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Study of Effects of Different Levels of Irrigation Interval, Nitrogen and Superabsorbent on Seed Yield and Morphological Traits of Sesame

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Abstract: In order to study the effect of different levels of irrigation interval, N and superabsorbent on seed yield and morphological traits of sesame, a split-split-plot experiment was conducted in Khosr Region, Birjand, Iran in 2009 based on a randomized complete block design. The main plot was irrigation interval at three levels (6, 12 and 18 days), the sub-plot was N fertilization at three levels (0, 100 and 200 kg/ha) and the sub-sub-plot was superabsorbent at two levels (0 and 200 kg/ha). The results of analysis of variance showed that irrigation interval significantly affected seed yield, plant height, stem diameter, auxiliary branch number per plant, first capsule distance from ground and capsule length, so that the increase in irrigation interval from 6 to 18 days decreased seed yield, plant height, stem diameter, auxiliary branch number per plant and capsule length by 44.5, 35.8, 64.3, 49 and 45.7%, respectively. N fertilization significantly affected all studied traits, so that the increase in N level from 0 to 200 kg/ha increased them by 26.6, 14.2, 55.8, 39.9 and 23.7%, respectively. Also, the effect of superabsorbent was significant on all traits except capsule length. In total, given the results of the study, it can be recommended to use irrigation interval of 6 days with the application of 200 kg N/ha in order to realize optimum yield 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 pharmaceutics, fuel and soap industries has arisen farmers' interest in its cultivation (Weiss, 1971) because cultivation of a multi-purpose crop allows meeting domestic demands and reducing the dependence on foreign countries. Sesame is a very valuable industrial crop which is known as the most ancient crop cultivated by human being (Hasheminia *et al.*, 1997; Asch, 2003). Various regions have been mentioned as its origin such as hot regions of northern Africa, northern states of the USA, India and Pakistan (Khajehpoor, 1999; Asch, 2003; Dudley, 2000). Because of their multiple functions in a plant, fertilizer and N are regarded as important factors in oilseed breeding.

Hassanzadeh *et al.*, (2009) reported that the difference in sesame seed yield was significant among irrigation treatments at 1% level, so that the highest yield (701.60 kg/ha) was obtained at fully-irrigated treatment. Dilip *et al.*, (1991) reported that the increase in irrigation frequency significantly increased auxiliary branch number. According to the results of the study of Bahrani and Babaei (2007), seed yield increased with N level where the highest seed yield was obtained at N level of 90 kg/ha. Papari Moghaddam Fard and Bahrani (2005) showed that the increase in N level up to 90 kg/ha significantly increased branch number per plant and seed yield of sesame. In a study on the effect of N on sesame, Sinharoy *et al.*, (1990) found that the application of 30 and 60 kg N/ha in two forms of urea and ammonium nitrate increased plant height and initial branch number per plant. The application of some amendments like superabsorbent polymers allows the storage and maintenance of water of diffuse precipitation and other limited sources in soil. Indeed, such amendments improve soil physical properties and help in avoiding moisture stresses in arid and semi-arid regions. Yazdani *et al.*, (2007) reported that soybean seed yield increased with the increase in superabsorbent level. In addition, they found that superabsorbent polymer can increase soybean yield under drought stress and also adequately-irrigated conditions. Therefore, the objective of the current study was to investigate the effect of different N and superabsorbent levels at various irrigation intervals on seed yield and morphological traits of sesame.

MATERIALS AND METHODS

The study was carried out in Khosf county, Birjand, Iran (Long. 59°13´ E., Lat. 32°53´ N., Alt. 1480 m) in 2009. It was a split-split-plot experiment based on a randomized complete block design with three replications. The main plot was irrigation interval at three levels of 6, 12 and 18 days, the sub-plot was N fertilizer at three levels of 0, 100 and 200 kg N/ha and the sub-sub-plot was superabsorbent at two levels of 0 and 200 kg/ha. The

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seeds were of a local landrace. Each plot was 6 m with 6 planting rows with inter-row spacing of 45 cm and inter-plant spacing of 5 cm. The soil was clay-sandy with 0.11% organic matter content, EC of 8.42 $dS.m^{-1}$ and saturated soil pH of 8.09. Soil preparation operation included plowing, disking and leveling which were carried out in April 2009. The seeds were manually sown at the depth of 1.5-2.5 cm on June 20. The seeds were disinfected with fungicide Benomyl 2:1000 before sowing and were manually weeded during growth period. The plants were thinned at 6-leaf stage in order to have the desired plant density and the irrigation treatments were applied. The treatment of N fertilizer from urea source was applied at three stages (post-thinning, early-flowering and late-flowering). 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 before sowing at the depth of 20-25 cm in the middle of furrows.

Before harvesting, 10 plants were selected from two middle rows and then, their morphological traits including plant height, stem diameter, auxiliary branch number per plant, first capsule distance from the ground and capsule length were measured. The plants were harvested from an area of 2 m^2 in November when they almost turned yellow but the capsules were not split yet. Then, they were dried in open air, the seeds were separated from capsules and seed yield (with 10% moisture) was measured. Finally, the data were statistically analyzed by MSTAT-C and the means were compared by Duncan Test at 5% level.

RESULTS AND DISCUSSION

Seed Yield:

The results of analysis of variance showed that the effect of irrigation interval, N level and their interaction was significant on seed yield at 1% statistical level, but superabsorbent application and other interactions did not significantly affect it (Table 1). The highest seed yield with an average amount of 687.04 kg/ha was obtained under the irrigation interval of 6 days which was 32 and 80.2% greater than that under the irrigation intervals of 12 and 18 days, respectively (Table 2). This was because of the decrease in inter-plant competition and the increase in auxiliary branch number and capsule number per plant. These results are in agreement with those of Rezvani Moghaddam *et al.,* (2005) and Praksh and Thimmegoawd (1991) about sesame.

Means comparison for seed yield at different N levels showed 6.5 and 25.6% superiority of fertilizer level of 200 kg N/ha over fertilizer levels of 100 and 0 kg N/ha, respectively (Table 2). Also, Papari Moghaddam Fard and Bahrani (2005) showed the significant increase in seed yield with the increase in N level.

Although the increase in N level had a positive effect on seed yield at all irrigation levels, the effect was much greater at optimum irrigation level. According to the means comparison for interaction between irrigation level and N, the highest seed yield with an average amount of 770.37kg/ha was obtained under the irrigation interval of 6 days with the application of 200 kg N/ha which was 31.2% greater than that obtained under the irrigation interval of 6 days with no-fertilization (Table 3). Increased availability of water and N provided optimum conditions for vegetative growth and increased photosynthesis level, the production of assimilates, capsule number per plant and seed number per capsule, and finally, it significantly increased seed yield. Seed yield had positive significant correlation with plant height, stem diameter, auxiliary branch number per plant and capsule length at 1% level (Table 4). This showed that plant potential yield was improved with the increase in either trait.

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

Sources of variation	df	Seed yield (kg/ha)	Plant height (cm)	Stem diameter (mm)	Auxiliary branch number/plant	1st capsule distance from ground (cm)	Capsule length (mm)
Replication	2	1627.230^{ns}	15.422^{ns}	1.823^{ns}	12.601**	0.039^{ns}	16.363^{ns}
Irrigation	2	422069.600**	1944.611**	115.986**	128.151**	34.272**	743.82**
Error *a*	4	1580.076	4.264	1.337	0.164	0.161	2.263
N	2	66687.245**	181.252**	25.283**	33.101**	7.571**	99.004**
Irrigation × N	4	6087.107**	45.179**	2.028^{ns}	6.244**	2.436**	9.019**
Error *b*	12	320.073	5.979	1.211	0.223	0.193	1.278
Superabsorbent	1	825.331^{ns}	20.418^{ns}	6.240^{ns}	0.829^{ns}	0.033^{ns}	4.194**
Irrigation × superabsorbent	2	415.523^{ns}	9.146^{ns}	4.107^{ns}	0.139^{ns}	0.814**	0.616^{ns}
N × superabsorbent	2	29.721^{ns}	3.733^{ns}	1.501^{ns}	0.136^{ns}	0.983**	0.257^{ns}
Irrigation × N × superabsorbent	4	180.613^{ns}	2.686^{ns}	0.535^{ns}	0.647^{ns}	0.273*	0.327^{ns}
Error *c*	18	301.783	10.532	1.865	0.742	0.078	0.44
C.V. (%)		3.28	6.87	25.22	10.72	1.79	3.02

ns, * and ** show non-significance and significance at 5 and 1% level, respectively.

Table 2: Means comparison of the effects of irrigation interval, N and superabsorbent on seed yield and morphological traits of sesame.

Treatment	Seed yield (kg/ha)	Plant height (cm)	Stem diameter (mm)	Auxiliary branch number/plant	1st capsule distance from ground (cm)	Capsule length (mm)
Irrigation interval (day)						
6	687.04 a	57.99 a	7.88 a	10.84 a	14.37 c	27.79 a
12	520.68 b	46.58 b	5.56 b	7.73 b	15.39 b	23.08 b
18	381.17 c	37.24 c	2.81 c	5.53 c	17.10 a	15.08 c
N (kg/ha)						
0	462.35 c	43.79 c	4.25 c	6.76 c	16.37 a	19.41 c
100	545.68 b	48.02 b	5.38 b	7.87 b	15.33 b	22.52 b
200	580.86 a	50.00 a	6.62 a	9.46 a	15.17 b	24.01 a
Superabsorbent (kg/ha)						
0	525.72 a	46.65 a	5.08 a	7.91 a	15.60 a	21.70 b
200	533.54 a	47.88 a	5.76 a	8.15 a	15.65 a	22.26 a

Means of traits at each column with similar letter(s) were not significant at 5% level.

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

Irrigation interval (day)	N level (kg/ha)	Seed yield (kg/ha)	Plant height (cm)	Auxiliary branch number/plant	1st capsule distance from ground (cm)	Capsule length (mm)
6	0	587.04 c	52.14 c	8.94 c	15.05 b	25.34 bc
	100	703.70 b	57.60 b	10.00 b	13.82 c	27.39 b
	200	770.37 a	64.23 a	13.57 a	14.26 c	30.65 a
12	0	452.78 e	43.75 e	7.11 e	16.83 a	21.55 d
	100	541.67 d	48.50 d	7.77 d	15.02 b	23.50 cd
	200	567.59 cd	47.48 d	8.32 d	14.33 c	24.18 c
18	0	347.22 g	35.47 f	4.24 h	17.23 a	11.35 f
	100	391.67 f	37.96 f	5.84 g	17.15 a	16.68 e
	200	404.63 f	38.28 f	6.49 f	16.93 a	17.20 e

Means of traits at each column with similar letter(s) were not significant at 5% level.

Table 4: Coefficients of correlation of traits between seed yield and morphological traits of sesame.

Traits	1	2	3	4	5	6
Seed yield (kg/ha)	1					
Plant height (cm)	0.938**	1				
Stem diameter (mm)	0.870**	0.808**	1			
Auxiliary branch number/plant	0.912**	0.846**	0.848**	1		
1st capsule distance from ground (cm)	-0.874**	-0.809**	-0.776**	-0.725**	1	
Capsule length (mm)	0.917**	0.902**	0.844**	0.832**	-0.836**	1

** shows significance at 1% level.

Plant Height:

According to the results of analysis of variance, irrigation interval, N level and their interaction significantly affected plant height at 1% statistical level, but the effect of superabsorbent application and other interactions was not significant (Table 1). The highest plant height was associated with the irrigation interval of 6 days with an average amount of 58 cm which was 24.5 and 55.7% greater than that produced under the irrigation intervals of 12 and 18 days, respectively (Table 2). Probably, intensified drought stress increased inter-plant competition and so, plant allocated more assimilates to the roots whereby less assimilates were allocated to shoots including stem. Therefore, plant height tended to decrease. The results are in agreement with the results of Rezvani Moghaddam *et al.*, (2005) and Yazdani *et al.*, (2007).

Means comparison for plant height at different N levels indicated that the application of 200 kg N/ha resulted in 4.1 and 14.2% higher plant height than the application of 100 and 0 kg N/ha, respectively (Table 2). In the study of Ahmadi and Bahrani (1388) too, the increase in N level led to a significant increase in plant height.

Although the increase in N level had positive effect on plant height at all irrigation intervals, the effect was much greater at optimum irrigation conditions, so that the increase in N level from 0 to 200 kg/ha at irrigation interval of 6 days increased plant height by 23.2% while it was only 7.9% at irrigation interval of 18 days (Table 3). According to the means comparison, the highest plant height (64.2 cm) was obtained under the irrigation interval of 6 days with the application of 200 kg N/ha which was 23.2% greater than that under irrigation interval of 18 days with no-fertilizer application which resulted in plant height of 35.5 cm (Table 3). The increased availability of both water and N provided optimum conditions for plants vegetative growth and improved photosynthesis rate and assimilate production and finally, significantly increased plant height.

Stem Diameter:

Stem diameter was significantly affected by irrigation interval and N level at 1% statistical level but not by superabsorbent and the interactions (Table 1). As irrigation interval was increased from 6 to 18 days, stem diameter decreased from 7.9 to 2.8 mm, i.e. a 64.3% decrease (Table 2). It appears that as irrigation interval was decreased, the availability of water increased and then, leaf area index, photosynthesis rate and the allocated and

stored assimilates in stem increased which led to the rise of stem diameter. Ja'farzadeh Kenarsari and Poostini (1997) found similar results for sunflower.

According to means comparison, the highest stem diameter with an average amount of 6.6 mm was obtained under N level of 200 kg/ha which was 23 and 55.8% greater than that under N levels of 100 and 0 kg/ha, respectively (Table 2). N fertilizer application might have increased stem diameter by stimulating vegetative growth and extending leaf area duration.

Auxiliary Branch Number Per Plant:

As the results of analysis of variance showed, the effect of irrigation interval, N level and their interaction was significant on auxiliary branch number per plant at 1% statistical level, but superabsorbent application and other interactions did not significantly affect it (Table 1). The increase in irrigation interval decreased auxiliary branch number per plant, so that the highest auxiliary branch number per plant (10.8 on average) was obtained under the irrigation interval of 6 days which was 40.2 and 96% greater than that under irrigation intervals of 12 and 18 days, respectively (Table 2). The studies of Rezvani Moghaddam *et al.,* (2005), Ghangard *et al.,* (1991) and Kharwara and Bindra (1992) on sesame showed significant decrease in auxiliary branch number per plant with the increase in irrigation interval. This decrease could be related to the decrease in photosynthesis potential and whereby, the decrease in sesame plant height under water deficit stress.

Means comparison indicated that the application of 200 kg N/ha produced the highest auxiliary branch number per plant (9.5 on average) which was 20.2 and 39.9% higher than that produced with the application of 100 and 0 kg N/ha, respectively (Table 2). Seemingly, the increase in N level stimulated vegetative growth and increased plant height and auxiliary branch number per plant. These results are in agreement with the results of Ahmadi and Bahrani (2009), Papari Moghaddam Fard and Bahrani (2005) and Sinharoy *et al.,* (1990).

Means comparison of the interaction between irrigation and N showed that when enough moisture was provided for the plants, the increase in N level considerably increased auxiliary branch number per plant, so that the treatment of irrigation interval of 6 days with the application of 200 kg N/ha produced the highest auxiliary branch number per plant (13.6 on average) which was 220% higher than that produced under the treatment of irrigation interval of 18 days with no-fertilizer application (Table 3). It appears that when there is a water deficit, plants absorb less water which in turn, decreases their vegetative growth and the number of auxiliary branch per plant. Though, it should be noted that under the conditions of the current study, the increase in N level partly increased sesame branch-bearing potential even under the most severe water deficit condition. Yoshida (1975) showed that the increase in N level had positive effect on growth parameters provided that there was enough moisture.

First Capsule Distance from Ground:

The results of analysis of variance showed that irrigation interval and N fertilizer significantly affected first capsule distance from ground at 1% level (Table 1). The decrease in irrigation interval decreased first capsule distance from ground so that the greatest first capsule distance from ground (17.1 cm on average) was obtained under the irrigation interval of 18 days (Table 2).

It seems that as irrigation interval was reduced, the competition on resources particularly water started to decrease and more favorable conditions were provided for the growth and production of assimilates; hence, branch-bearing was accelerated and the first capsule distance from ground decreased too.

According to the means comparison, the greatest first capsule distance from ground (16.4 cm on average) was obtained under the treatment of no-fertilizer application (Table 2). Ahmadi and Bahrani (2009), Papari Moghaddam Fard and Bahrani (2005), Ramakrishnan *et al.,* (1996) and Sinharoy *et al.,* (1990) reported similar results. Probably, sesame potential photosynthesis does not realize under N deficiency and so, fertile branches emerge later and first capsule distance from ground increases.

The interactions of irrigation interval × N, irrigation interval × superabsorbent and N × superabsorbent significantly affected first capsule distance from ground at 1% statistical level and the interaction of irrigation interval × N × superabsorbent significantly affected it at 5% level, but superabsorbent application did not make any significant differences in it (Table 1). The lowest first capsule distance from ground (13.8 cm on average) was obtained under the treatment of irrigation interval of 6 days with the application of 200 kg N/ha (Table 3). Means comparison of interaction between irrigation interval and superabsorbent indicated that the greatest first capsule distances from ground (17.09 and 17.11 cm on average) were obtained under the treatment of irrigation interval of 18 days with no-superabsorbent application and the treatment of irrigation interval of 18 days with the application of 200 kg superabsorbent/ha, respectively (Fig. 1). In addition, under no-fertilizer application, the greatest first capsule distances from ground were on average 16.5 and 16.2 cm with the application of 0 and 200 kg superabsorbent/ha, respectively (Fig. 2). Perhaps, with no-fertilizer application at different superabsorbent levels, plants cannot uptake it and hence, sesame photosynthesis and growth decrease and as a result, first capsule distance from ground increases. The treatment of irrigation interval of 6 days with the application of 100 kg N/ha with no-superabsorbent application produced the lowest first capsule distance from

ground (13.4 cm on average) which was 24% lower than that obtained under the treatment of irrigation interval of 18 days with the application of 100 kg N/ha and 200 kg superabsorbent/ha whose first capsule distance from ground was on average 17.7 cm.

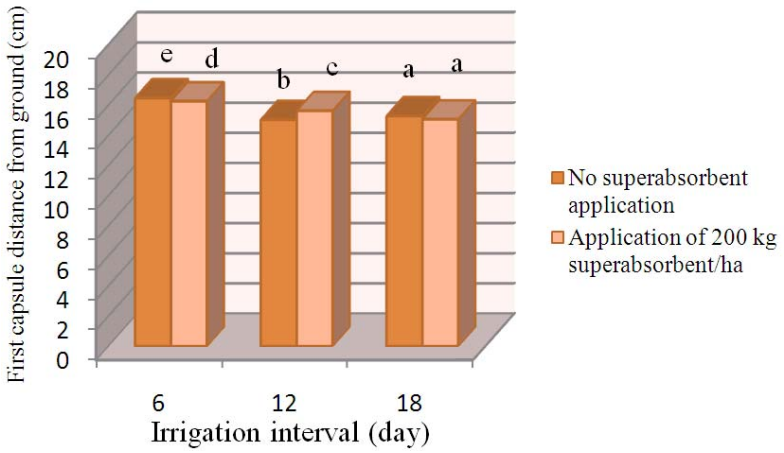

Fig. 1: Interaction of irrigation interval and superabsorbent on first capsule distance from ground. (Columns with the same letter(s) were not significant at 5% level).

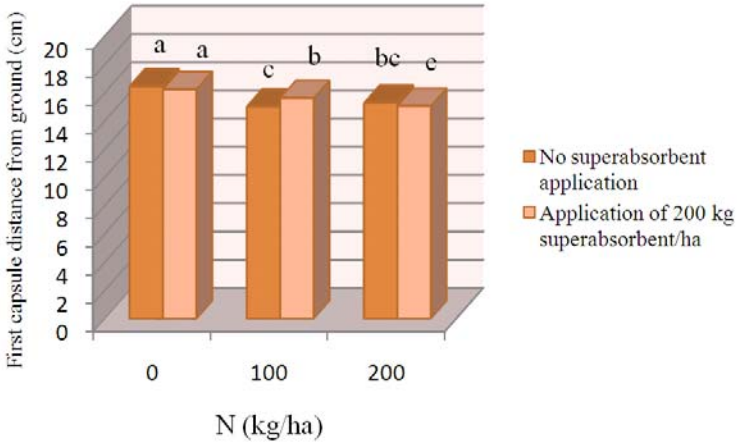

Fig. 2: Interaction of irrigation interval and superabsorbent on first capsule distance from ground. (Columns with the same letter(s) were not significant at 5% level).

Capsule Length:

As the results of analysis of variance indicated, the effect of irrigation interval, N and superabsorbent as well as the interaction between irrigation interval and N was significant on capsule length at 1% statistical level, but other interactions did not significantly affect it (Table 1). The highest capsule length (27.8 mm on average) was obtained under the irrigation interval of 6 days which was 20.4 and 84.3% higher than that obtained under the irrigation intervals of 12 and 19 days, respectively (Table 2). It might be because of more favorable conditions for plants growth under optimum irrigation (no-stress) conditions and so, allocation of assimilates to the lengthening of capsules and production of more seeds in them.

Means comparison of capsule length at different N levels showed that the treatment of the application of 200 kg N/ha had longer capsules than the treatments of the application of 100 and 0 kg N/ha by 6.6 and 23.7%, respectively (Table 2). Majiri and Arzani (1382) and Miller and Fick (1978) found similar results for head diameter of sunflower.

The longest capsules (22.3 mm on average) were produced under the treatment of the application of 200 kg superabsorbent/ha which were 2.6% longer than those under no-superabsorbent application treatment (Table 2). Probably, superabsorbent helps in mitigating stress and increasing nutrient uptake by plants through its slowly-nutrient-releasing characteristic whereby it increases capsule length of sesame.

Although the increase in N level had positive effect on increasing capsule length under all irrigation levels, this effect was much greater and more significant under optimum irrigation conditions, so that the longest capsules (30.7 mm on average) were produced under the treatment of irrigation interval of 6 days with the application of 200 kg N/ha which were 21% longer than those produced under the treatment of irrigation interval of 6 days with no-fertilizer application (Table 3). The increase in water and N availability provided optimum conditions for the vegetative growth and led to the increase in photosynthesis rate and production of assimilates which at the end, significantly increased capsule length.

Conclusion:

In total, on the basis of the results of the study, it can be concluded that supplying enough water and N can increase sesame seed yield via significantly increasing most morphological traits and therefore, it is recommended to use irrigation interval of 6 days accompanied with the application of 200 kg N/ha in order to realize high economical yield under the conditions of the current study. It should be noted that superabsorbent application in sesame cultivation exactly under the rows is likely to have positive effect on vegetative and reproductive growth potential and potential yield but it needs further study.

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