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Investigation of Water Stress on Yield and Yield Components of Sesame (*Sesamum indicum* L.) in Moghan Region

[1]M. Hassanzadeh, [2]A. Ebadi, [3]M. Panahyan-e-Kivi, [1]Sh. Jamaati-e-Somarin, [1]M. Saeidi and [2]A. Gholipouri
[1]Young Researchers Club, Department of Agronomy, Faculty of Agriculture, Islamic Azad University, Ardabil Branch, Ardabil, Iran
[2]Department of Agronomy and Plant Breeding, Faculty of Agriculture, University of Mohaghegh Ardabili, Ardabil, Iran
[3]Department of Agronomy, Payam Noor University, Ardabil, Iran

Abstract: In order to investigate the effects of water stress on yield and yield components of 27 sesame genotypes, a factorial experiment based on randomized complete block design with three replications was conducted in 2006 in Moghan region, Iran. Factors were, 27 sesame genotypes (Karaj 1, Yekta, Oltan, Moghan 17, Naz takshakheh, Naz chandshakheh, Borazjan 2, Borazjan 5, Darab 14, Varamin 37, Varamin 237, Varamin 2822, Zoodrass IS, Hendi, Chini, Yellow white, 5089, Panama, Do-1, TF-3 , TKG-21, J-I, RT-54, Hendi 9, Hendi 12, Hendi 14 and Jiroft) and second factor was irrigation levels (complete irrigation and irrigation until flowering). Results showed that the highest yield belonged to Karaj1, Oltan, Naz takshakheh and Varamin 237 of 861.87, 863.47 and 859.73 kg ha^{-1}. Naz takshakheh had the highest 1000-seed weight of 3.771 g. The highest seed No. per capsule and No. of capsule per plant was related to Chini and Naz chandshakheh genotypes of 107.250 and 99.13, respectively. So, Karaj 1, Oltan, Naz takshakheh and Varamin 237 genotypes in order to planting under drought stress conditions are recommended.

Key words: Sesame genotypes, drought stress, yield and yield components

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest crop plants. This crop, for a long time, has been planted in warm and arid areas all around the world and has been adapted to these conditions. Drought stress is one of the most important environmental factors limiting sesame yield in high intensities (Betram *et al*., 2003). Rate and distribution of seasonal precipitation, difference in temperature and soil conditions are the main factors affecting yield and yield components of sesame in arid and semi-arid regions (Nath and Chakrabotry, 2001). Water requirement of sesame under semi-arid conditions was calculated about 915 mm (Sepaskhah an Andam, 2001). Ghosh *et al*. (1997) observed the highest sesame yield with three irrigations than two and one irrigations. Mensah *et al*. (2006) indicated that sesame seed had higher germination ability in poly ethylene glycol (PEG) solution than glucose and natrium chloride (NaCl) solutions. Also, it was cleared that water stress had unfavorable effects on plant height, leaf area and plant dry matter of sesame. Sesame is sensitive to

Corresponding Author: Sh. Jamaati-e-Somarin, Young Researchers Club, Department of Agronomy, Faculty of Agriculture, Islamic Azad University, Ardabil Branch, Ardabil, Iran
Tel: +989141594490

water deficit at seedling (low root expanding), flowering and seed filling stages (high leaf area index and producing meristemic tissues) and can led to yield loss (Alizadeh, 2002). Excessive values of water like water stress, causes plants such as sesame, are wilted. Also, dehydration may result in senescence and fall of the basal leaves and then, in upper young leaves. Jiang and Huang (2001) found that water stress decreased the ratio of main stem grain yield of determinate soybean to total plant grain yield. In these conditions, watered soybean had the low rate of harvest index in main stems. Water stress, during the growth stages of the maize, led to decrease in plant height and leaf area index (Cassel *et al*., 1985). Total yield and final grain number during seed filling period under drought stress was decreased (Ritchie *et al*., 1993). Sinaki *et al*. (2007) found that biological yield of soybean under moderate and severe drought stresses, was decreased of 20.7 and 31.2% than control, respectively. Jiang and Huang (2001) indicated that drought stress had no effect on number of main stems and grain number of main stems of soybean per unit area. Also, relationship between main stem grain yield and weight of each grain in main stems was not significant. Ucan *et al*. (2007) showed that with increasing the irrigation numbers, sesame yield was decreased. On the contrary, Tantawy *et al*. (2007) reported that with decreasing the irrigation, sesame yield was decreased. Kim *et al*. (2006) found that drought stress caused a large decrease in seed yield per plant but did not affect the mean weight of individual seeds, showing that sesame responds to post-flowering drought by reducing seed numbers, but not seed size.

The aim of this study was investigation of effects of drought stress on yield and yield components of 27 sesame genotypes and evaluation of correlations between yield components under stress and normal conditions in order to selecting genotypes having high and stable yields under these conditions in Moghan region, Iran.

MATERIALS AND METHODS

In order to investigation of drought stress effect on drought tolerance indices of sesame genotypes in Moghan region, Iran, a factorial experiment based on randomized complete block design with three replications was laid out in 2006. First factor was 27 sesame genotypes (Karaj1, Yekta, Oltan, Moghan 17, Naz takshakheh, Naz chandshakheh, Borazjan 2, Borazjan 5, Darab 14, Varamin 37, Varamin 237, Varamin 2822, Zoodrass IS, Hendi, Chini, Yellow white, 5089, Panama, DO-1, TF-3, TKG-21, J-1, RT-54, Hendi 9, Hendi 12, Hendi 14 and Jiroft) and second factor was irrigation levels: (complete irrigation and irrigation until flowering stage in 10-12 day intervals). The region was semi-arid with warm summers and moderate winters located at 39°39' latitude and 47°18' altitude. Based on soil test, organic carbon rate was 1.75%, phosphorus of 7 mg kg^{-1}, potassium of 700 mg kg^{-1} and soil salinity was < 2 dm m^{-2}. Crop was planted on July 2006. Each genotype was sown in four 4 m rows spaced 60 cm apart. Distance of plants in rows was 4 cm in depth of 1-2 cm. The rate of 50 kg ha^{-1} nitrogen and phosphorus was applied before planting as soil incorporation. One hundred kilogram per heacter nitrogen was applied during the season, as well. In order to determination yield, plants of two middle rows of each plot were harvested and transferred to laboratory. By the way, genotypes were classified based on the rate of yield using cluster analysis (Fig. 1) into three distinct groups (data not shown). Measured traits were: No. of seed per capsule, number of capsule per plant, 1000-seed weight and yield per plot and yield per hectare. Data were subjected to analysis using SAS and SPSS and graphs were drawn using Excel softwares. Mean comparisons were done with Duncan's multiple range test.

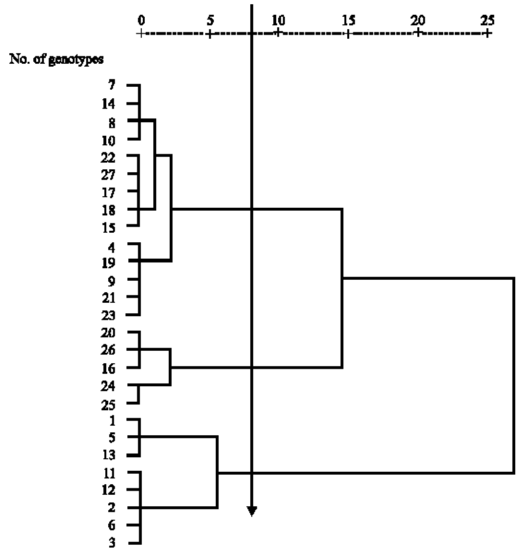

Fig. 1: Dendrogram of classified genotypes using cluster analysis

RESULTS AND DISCUSSION

Grain Yield

Grain yield among irrigation treatments and genotypes ($p<0.01$) was significant. The highest yield was obtained from complete irrigation of 701.60 kg ha^{-1} (Table 1). The most grain yield was observed in Karaj 1, Oltan and Naz takshakheh genotypes of 861.87, 863.47 and 859.73 kg ha^{-1} and the least grain yield belonged to Hendi 12 genotype of 218.27 kg ha^{-1} (Table 1). Karaaslan *et al*. (2007) demonstrated that with increasing the irrigation intervals from 6-day-intervals to 18 and 24-day-intervals, sesame yield was decreased from 1790-1550 and 1130 kg ha^{-1}. This result confirms present findings which urge yield loss as a result of water deficit. In the contrary, some studies states adverse findings. Mensah *et al*. (2006), for example, reported that with increasing the irrigation intervals from daily to each 15 days, grain yield increased from 5.9 and 6.09 g plant^{-1}, but in this study, irrigation withholding after flowering caused significant yield loss which may ascribed to reduction of available water for plant in order to increasing the final plant dry matter. It seems that sesame is sensitive to excessive amount of water and these rates, decrease yield. This is probably because of water-logging like effect of more watering to sesame roots. Hence, up to definite mark, irrigation increase can increase sesame yield and its deficit, can damage plant life. Fredrick *et al*. (2001) indicated that water deficit had significant effect on yield of lateral stems of soybean and its yield under normal conditions was more than stress conditions. In this plant, water stress decreased grain yield by decreasing the grain weight. Since, water deficit after flowering and early grain filling period, doesn't decrease No. of grains (sink) so, it reduces grain weight (Sinaki *et al*., 2007).

1000-Seed Weight and No. of Seed per Plant

Effects of irrigation and genotype treatments on 1000-seed weight ($p<0.01$) was significant. This trait significantly was different in irrigation and stress. In complete irrigation, mean 1000-seed weight was 3.454 g and in stress was 2.479 g. Naz takshakheh had the highest value of 3.771 and Hendi 12 had the lowest value of 1.844 g (Table 1). Also, No. of seed per capsule significantly was affected by irrigation and genotype treatments (Table 1). Mean number of seed per capsule in complete

Table 1: Mean comparisons of main effects of genotypes and irrigation levels on measured traits

Treatments	No. of capsule per plant	No. of seed per capsule	1000-seed weight (g)	Grain yield (kg ha^{-1})
Irrigation levels				
Irrigation	86.290a	86.280a	3.454a	701.60a
Drought stress	67.560b	77.810b	2.479b	493.43b
High yielding genotypes				
Karaj 1	80.450bcde	79.400bc	3.6258ab	861.87ab
Yekta	73.113cdef	84.433b	3.4087abcd	766.80abcd
Oltan	72.583cdef	81.467bc	3.6109abc	863.37ab
Zoodrass IS	71.115cdef	77.535bc	3.129abcdef	859.73ab
Naz takshakheh	83.750abc	79.233bc	3.7715a	886.27a
Naz chandshakheh	99.133a	66.500d	3.4123abcd	735.20abcde
Varamin 237	70.017cdef	81.067bc	3.4224abcd	806.40abc
Varamin 2822	83.717abc	80.850bc	3.1386abcdef	649.60bcdefg
Medium yielding genotypes				
Moghan 17	76.350bcdef	85.350b	2.6878defgh	550.40defgh
Varamin 37	60.850f	85.950b	3.3938abcde	606.53cdefg
Borazjan 2	81.250abcd	74.583c	3.1811abcdef	669.73bcdef
Borazjan 5	83.200abc	82.517bc	2.8386bcdefg	597.73cdefg
Darab 14	74.350cdef	84.067bc	3.0851abcdef	507.20fghi
Hendi	79.350bcdef	79.133bc	3.1786abcdef	586.80defg
Chini	61.900ef	107.250a	2.6787defgh	573.73defg
Jiroft line	64.083def	77.517bc	3.0639abcdef	528.67efgh
5089	86.583abc	80.767bc	2.6436defgh	580.53defg
Panama	71.300cdef	85.400b	2.9262bcdefg	537.87efgh
DO-1	83.200abc	82.900bc	2.5876efgh	481.20fghi
RT-54	70.700cdef	86.417b	2.7651defg	518.67efgh
TKG-21	75.917bcdef	81.950bc	2.9355bcdefg	586.93defg
J-1	61.417f	86.000b	3.1504abcdef	558.53defgh
Low yielding genotypes				
TF-3	73.500cdef	79.850bc	2.8049cdefg	515.73efgh
Hendi 9	93.450ab	79.773bc	1.9643hi	300.67ij
Hendi 12	67.967cdef	79.417bc	1.8445i	218.27j
Hendi 14	26.583abcd	78.300bc	2.1524ghi	349.60hij
Yellow white	84.950abc	82.133bc	2.5013fghi	434.80ghi

Means with the same letter(s), have no significant difference to each other

irrigation and stress was 86.28 and 77.81, respectively but Mensah *et al*. (2006) reported that with decreasing the available water for plant, No. of seed per plant was increased. Generally, in the majority of crop plants, with increasing the water stress, No. of seeds per plant is decreased because, water deficit at the flowering time, results in sterilization of some of flowers and consequently, leads to decrease in total seed No. per plant. Moreover, they reported that with decreasing the watering in sesame, 1000-seed weight significantly was increased. These two findings are opposite to present results. It is clear that water stress decreasing the stored matters of the seed, decreases seed weight. Also, Bismillah Khan *et al*. (2001) concluded that No. of seed per unit area and seed weight of corn strongly were reduced under drought conditions. They found that with increasing the irrigation times, No. of seed was increased. Also, Sinaki *et al*. (2007) stated that exerting water stress on soybean decreased seed weight from 3.3-3.1 g. These findings are in accordance with present results. Chini genotype had the most seed per capsule of 107.25 and Naz chandshakheh had the least see per capsule of 66.5 (Table 1).

No. of Capsule per Plant

Number of capsule per plant was affected by irrigation and genotype. Under irrigation, the mean capsule per plant was of 86.29 and under stress; the least one was of 67.56. Naz chandshakheh and J-I genotypes had the most and the least capsule per plant of 99.13 and 61.41, respectively (Table 1). Mensah *et al*. (2006) observed that with increasing the irrigation intervals in sesame, No.

Table 2: Correlations between measured traits

Measured traits	No. of capsule per plant	No. of seed per capsule	1000-seed weight	Grain yield
No. of seed per capsule	0.38**	1.00		
1000-seed weight	0.17**	0.07^{ns}	1.00	
Grain yield	0.41**	0.26**	0.14**	1.00

^{ns}, * and ** are non significant, significant at p<0.01 and significant at p<0.05, respectively

of capsule per plant significantly decreased. Also, Karaaslan *et al*. (2007) found that in these irrigation intervals: 6, 12, 18 and 24 days, No. of capsule per plant was 83.7, 77.5, 85.5 and 74.3, respectively. This means that water stress decreased this trait. These findings are in agreement with present results. In low moisture and/or fertility conditions, the plant may not even form the axillary flowers (Ray Langham, 2007). These types of flowers can produce axillary capsules and consequently, can produce more capsules per plant.

Correlation Coefficient

As shown in Table 2, No. of capsule per plant with No. of seed per capsule, 1000- seed weight and yield had positive and significant correlation. Also, No. of seed per capsule had the positive and significant correlation with yield. 1000-seed weight had the positive and significant correlation with yield, as well. In other words, increase in No. of capsule per plant, No. of seed per capsule and 1000-seed weight (as yield components), increased plant yield.

CONCLUSION

Genotypes in this research were very different and their origins were of miscellaneous regions so, selection of genotypes having all favorite trait such as highest rates of yield components is difficult but according to the results, Naz chandshakheh genotype among other genotypes was at highest levels about No. of capsule per plant. Also, Chini and Naz takshakheh had the highest seed per capsule and 1000-seed weight, respectively. Karaj 1, Oltan and Naz takshakheh had the most seed yield. According to the results, Naz takshakheh had the most seed yield and 1000-seed weight, Naz chandshakheh had the most capsule per plant so, these genotypes (with the close family relations) can be introduced as superior genotypes. Eventually, according to cluster grouping, it can be said that above mentioned genotypes (as high yielding genotypes) other than Chini genotype, can be recommended planting under rain fed conditions.

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