INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 8, p. 104-109, 2013

RESEARCH PAPER OPEN ACCESS

Investigation of water deficit stress effects on yield and yield components of four soybean cultivars at different growth stages

Mohammad Mehdi Pour Siahbidi[1*], Alireza Pour Aboughadareh[2], Abdolreza Bazdar[3], Mohammad Reza Naghavi[4]

[1]*Agricultural and Natural Research Center of Ilam, Ilam, Iran*

[2]*Department of Plant Breeding and Biotechnology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran*

[3]*Agriculture Organization of Ilam, Iran*

[4]*Department of Agriculture, Payame Noor University, PO.BOX 19395-4697 Tehran, Iran*

Key words: Agro-morphological traits, grain yield, soybean, water stress.

doi: http://dx.doi.org/10.12692/ijb/3.8.104-109 Article published on August 20, 2013

Abstract

In order to evaluate effects of water deficit stress on yield and yield components of four soybean cultivars (Sahar, Williams, Hobit and Harcor), an experiment was conducted in the Agricultural Research Station in Shirvan Chardavul, Ilam, Iran in 2010. The experiment was arranged as split plot based on randomized complete block design in three replicates. The stress conditions consisted of three different levels of water deficit stress: I_1: irrigation during all growth stages as control treatment, I_2: omit irrigation at the onset of flowering stage (R_1) and I_3: omit irrigation at the onset of grain filling stage (R_6). Results showed that water deficit stress had significant effect on number of pod, number grain per pod, number of grain per plant, 100grain weight, grain yield and biological yield. Also all of agro-morphological traits except harvest index influenced significantly by cultivars. The highest reduce of traits were at I_2 to I_3. In general, grain yield and yield components decreased with increasing water deficit. Therefore, water deficit can reduce the grain yield and its components however, the most grain yield and yield components was belonged to 'Sahar' and 'Harcor' cultivars under stress and non-stress conditions. Thus, these cultivars can be the most tolerant than other cultivars and the grain filling stage was the most sensitive growth stage of soybean to water deficit stress in this region.

* **Corresponding Author:** Mohammad Mehdi Pour Siahbidi ✉ m.siahbidi@gmail.com

Introduction

The soybean is one of the most important crops in the world. It is an important source of protein in the human food and has been utilized in the formulation of the animals' rations, besides utilization of the grain oil. The most worldwide yield is belonged USA, followed of Brazil, Argentina and China, they are responsible for about 90% of the world yield (Vendruscolo *et al.,* 2007). It's the most important oil crop after canola as seed production. Abiotic stresses can damage *Glycine max* L. Merrill, extremely. It is more sensitive than other food legumes, as *vigna unguiculata* (Roy-Macauley *et al.,* 1992; Silvieira *et al.,* 2003) and also with other crops as *Gossypium hirsutumand* and *sorghum bicolor* (Inamullah and El-shahaby, 2005). Agriculture worldwide is heavily dependent on water availability, making water management one of the most important components of modern agriculture. Water stress deficit is a serious problem for agriculture that reduces crop productivity. Therefore, improvement of drought tolerance in crop is a major objective of most crop breeding programs, particularly in arid and semi-arid areas of the world (Moustaf *et al.,* 1996). Dencic *at al.* (2000) reported that many morphological and physiological characteristics were affected by drought stress. Water deficit stress during the growth and development stages can be reduced yield, strongly (Van Heerden *et al.,* 2002). Moreover, yield and grain number were reduced as a result of water deficit stress during grain filling period. Thus, agronomic traits such as grain yield and its components are the major selection criteria for evaluating drought tolerance under field conditions. The most sensitive stages for soybean plants are pod development to seed filling. It needs adequate water in the soil to produce suitable yield. As the soybean plant develops from R1 (beginning bloom) through R5 (seed enlargement), the ability of plant decrease to tolerate the water deficit and produce low yield (Kranz *et al.,* 1998). Water deficit stress occurrence during flowering and early pod development stage increases the rate of pod abortion, significantly (Liu *et al*., 2003). As the soybean plant develops from R1 (beginning bloom) through R5 (seed enlargement), its tolerance decrease to drought. Some research showed that water deficit during flowering (R2 stage) had little effect on seed yield whereas during pod elongation (R3 stage) and seed filling (R5 stage) they were significant (Korte *et al.,* 1983). They also reported that water deficit stress at the flowering stage resulted in greater yield loss than the one at pod elongation stage. Water deficit during late reproductive development stage accelerates leaves aging and seed filling (Sionit and Kramer, 1997). Decreasing of the seed filling period may have a greater impact on yield than the direct effect of stress, such as reduced rate of photosynthesis. Although, the abortion of pods and seeds are occurred by water deficit during flowering and early pod development that may result in reducing of reproductive demand or critical assimilate reserves.

In this context the present work aimed to evaluate the grain yield and yield components of four soybean cultivars at three different water regimes in the field.

Materials and methods

An experiment was conducted at the Agricultural Research Station in Shirvan Chardavul, Ilam province, Iran (longitude 46° 36′E, latitude 33° 47′N, altitude 975 m above sea level) in 2010. The climate is characterized by mean annual precipitation of 616 mm, mean annual temperature of 16.9° C. The experiment was arranged as split plot on the basis of randomized complete block in three replicates, with water deficit stress treatments (I1, I2, and I3 for irrigation during all growth stages as control treatment, omit irrigation at the onset of flowering stage and omit irrigation at the onset of grain filling stage, respectively) in main plots and four cultivars (Sahar, Williams, Hobit and Harcor) in sub plots. Sowing was done by hand in plots with five rows 4 m in length and 60 cm apart. All plots were irrigated after sowing. Irrigation control was implemented in the evaporation of 60 mm from the basin evaporation during the whole growing stage. Water stress and non -irrigation treatments were conducted in each stages in order to assess the responses of developmental stage to stress conditions. There was no rainfall during the study. Some agro-morphological traits such as number of pod per plant, number of grain per pod, number of grain per plant, 100-grain weight, seed yield, biological yield and harvest index were determined. Analysis of variance appropriate for a split-plot design was carried out using General Linear Model procedure of SPSS software. Means of each trait for different treatments were compared according to Duncan multi rang test at 5% level of probability, using MSTATC software. Excel software was used to draw figure.

Results

Analysis of variance of the data showed that number of pod, number of grain per pod, number of grain per plant, 100-grain weight, grain yield and biological yield were significantly affected by water deficit stress. Also, this analysis indicated significant difference among cultivars in the terms of all traits except harvest index. The interaction of water deficit stress × cultivar for 100-grain weight was significant (Table 1).

Table 1. Analysis of variance for agro-morphological traits at different levels of water deficit stress.

Source	d.f	MS						
		Number of pod per plant	Number of grain per pod	Number of grain per plant	100-grain weight (gr/plant)	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Replication	2	3.65	0.002	44.05	0.648	11341.24	1710697.95	23.25
Stress	2	5049.66**	0.078*	33544.24**	33.338**	8895331**	64180000.00**	12.25^{ns}
E_a	4	13.16	0.008	158.25	0.608	36343.09	992539.418	32.75
Cultivar	3	964.66**	0.141**	3962.79**	4.718**	747563.1**	4610081.99*	70.44^{ns}
S * C	6	203.916^{ns}	0.002^{ns}	1273.73^{ns}	1.377*	168567.3^{ns}	679918.273^{ns}	36.25^{ns}
E_b	18	136.1	0.006	762.07	.443	100189.3	942867.797	39.176
CV (%)	-	15.7	3.41	16.13	4.45	15.15	18.17	15.65

ns, * and **: Non significant, significant at 5% and 1% levels of probability, respectively.

Table 2. Means of agro-morphological traits under different levels of water deficit stress.

		Number of pod per plant	Number of grain per pod	Number of grain per plant	100-grain weight (gr/plant)	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Levels of stress	I_1	94.71a	2.38a	225.35a	16.67a	299.36a	779.5a	38.91
	I_2	74.48b	2.26b	16853b	14.82b	199.51b	5026.8b	40.16
	I_3	53.69c	2.23b	119.71c	13.34c	127.94c	3204.6c	40.91
	V_1	82.84a	2.35a	197.61a	14.76b	2373a	6263.2a	37.22a
Cultivar	V_2	63.90b	2,34a	149.71b	15.21ab	1844b	4646.4b	41.22a
	V_3	66.89b	2.37a	160.08b	14.05c	1838.10b	4931.4b	38.22a
	V_4	83.55a	2.11b	177.39ab	15.76a	2302.50a	5530.7ab	43.33a

Different letters at each column indicate significant difference at 5% level of probability.

I_1, I_2 and I_3 indicate irrigation during all growth stages as control treatment, omit irrigation at the onset of flowering stage and omit irrigation at the onset of grain filling stage, respectively.

V1, V2, V3 and V4 indicate Sahar, Williams, Hobit and Harcor, respectively.

Number of pod per plant decreased under stress conditions. Thus, the difference between I1, I2 and I3 was significant. The highest number of pod per plant was obtained in I1. The highest amount of this trait related to 'Sahar' and 'Harcor' cultivars. Number of grain per pod decreased under stress condition. However, the difference between I2 and I3 was not significant. The highest number of grain per pod was belonged to 'Harcor' and 'Sahar' cultivars, respectively. Mean comparisons showed that the most decrease in number of grain per plant occurred in I3. Although, response of cultivars to water deficit stress were significant in number of grain per plod however, the different between 'Williams', 'Hobit' and 'Harcor' was not significant. The highest number of grain per plant was belonged to 'Sahar' cultivar. In all tested cultivars, water deficit reduced 100-grain weight (Fig. 1). Highest 100-grain weight amount in 'Harcor' of control condition and lowest amount of 100-grain weight in 'Hobit' cultivar in stress conditions of I3 was seen. Among different levels of stress condition, water deficit stress at I2 to I3, showed the lowest impact in reducing the 100-grain weight in four cultivars. In the I1 and I2 levels, most 100-grain weight obtained in 'Harcor' and 'Williams' respectively. However, in the I3 level most 100-grain weight obtained in 'Harcor' and 'Sahar' cultivars, respectively. In generally, among the tested cultivars in this experiment, 'Harcor' showed highest 100-grain weight in the different levels of water deficit stress, that can be cause of more tolerance of this cultivar to drought stress. Grain yield and biological yield under I2 and I3 was generally lower than that under I1. The highest grain yield and biological yield was belonged to 'Sahar' and 'Harcor' cultivars under I1 and I2 levels of water deficit stress conditions, respectively.

Discussion

All the alive and non-alive stresses are the most factors to reducing production nonetheless; drought stress is the most important factor limiting crops production in agricultural systems in arid and semi-arid regions (Molasadeghi *et al.*, 2011). Water deficit stress during the growth and development stages can be reduced yield, strongly (Van Heerden and Kruger, 2002). Our results clearly showed that grain yield and its components reduced under water deficit (Table 2). Decreasing components yield under water deficit in soybean (Table 2)

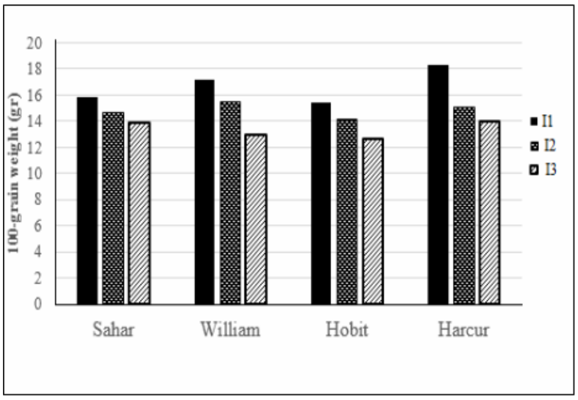

Fig. 1. Interaction of cultivars and water deficit stress on 100-grain yield in soybean.

I_1, I_2 and I_3 indicate irrigation during all growth stages as control treatment, omit irrigation at the onset of flowering stage and omit irrigation at the onset of grain filling stage, respectively.

supports the previous studies on wheat (Dencic *et al.*, 2000), barley (Pour Aboughadareh *et al.*, 2013), chickpea (Sori *et al.*, 2005), canola (Khalili *et al.*, 2012) and soybean (Ghasemi-Golezani *et al.*, 2013). As the soybean plant develops from R1 (beginning bloom) through R5 (seed enlargement), its tolerance decrease to drought. Korte *et al.* (1983) reported that water deficit during flowering (R2 stage) had little effect on seed yield whereas during pod elongation (R3 stage) and seed filling (R5 stage) they were significant. They also reported that water deficit stress at the flowering stage resulted in greater yield loss than the one at pod elongation stage. Drought stress occurrence during the early reproductive development stage increase the flower and pod abortion and decreasing the seed number in plant, but plant may produce high seed weight (Korte *et al.*, 1983). Number of pod per plant, number of grain per pod and plant the most important yield components of soybean that reduced under water deficit (Table 3). Desclaux *et al.* (2000) showed that stress occurrence at the onset of pod set stage and grain filling stage reduced the number of pod and grain per plant. They also reported abortion of flowers and pods due to water deficit in flowering stage as the main reason for reducing number of pod and grain per plant. Decreasing grain yield and biological yield under stress conditions (I1 and I2) are directly related to decreasing yield components such as number of pod per plant, number of grain per pod and plant (Table 3). According to Kobraei *et al.* 2011 the relationship between grain yield and components yield (number of pod, number of grain per pod and plant) is positively and significant therefore, decreasing these components may be reason for reducing grain yield and biological yield. Our results showed that harvest index was not effected by water deficit. This result is agreement with the results of Daneshian *et al.* (2010) and Kobraei *et al.* (2011) about the soybean responses to drought stress in terms of this traits. However, some research showed water deficit during flowering stage significantly reduced harvest index (Pandy *et al.,* 1984).

Conclusion

According to results of this study all traits except harvest index were affected by water deficit. Also, these results revealed that highest reduce of traits were at I_2 to I_3 and under water deficit 'Sahar' and 'Harcor' cultivars showed highest grain yield and yield components. Thus, these cultivars can be the most tolerant than other cultivars. On the other hand, the grain filling stage was the most sensitive growth stage of soybean to water deficit stress in this region.

References

Daneshian J, Jonoubi P, Tari-Barari D. 2010. Investigation of water deficit stress on agronomical traits of soybean cultivars in temperature climate. International Journal of Agricultural and Biological Sciences **1(2),** 75-82,

Dencic S, Kastori R, Kobiljski, B, Duggan B. 2000. Evaluation of grain yield and its components in wheat cultivars and landraces under optimal and drought conditions. Euphytica **113,** 43-52, http://dx.doi.org/10.1023/A:1003997700865

Desclaux D, Huynh TT, Roumet P. 2000. Identification of soybean plant characteristics that indicate the timing of drought stress. Crop Science **40,** 716-722, http://dx.doi.org/10.2135/cropsci2000.403716x

Ghasemi-Golezani K, Bakhshy J, Zehtab-Salmasi S, Moghaddam M. 2013. Changes in leaf characteristics and grain yield of soybean (*Glycine max* L.) in response to shading and water stress. International Journal of Biosciences **3(2),** 71-79, http://dx.doi.org/10.12692/ijb/3.2.71-79

Inamullah A, Isoda A. 2005. Adaptive responses of soybean and cotton to water stress. Plant Production Science **8(2),** 16-26,

Khalili M, Pour Aboughadareh AR, Naghavi MR, Talebzadeh SJ. 2012. Response of spring canola (*Brassica napus* L.) genotypes to water deficit stress. International Journal of Agriculture and Crop Science **4(21),** 1579-1586.

Kobraei S, Etminan A, Mohammadi R, Kobraei S. 2011. Effects of drought stress on yield and yield components of soybean. Annals of biological Research **2(5),** 504-509,

Korte LL, Williams JH, Specht JE, Sorensen RC. 1983. Irrigation of soybean genotypes during reproductive ontogeny. I. Agronomic response. Crop Science **23,** 521-527, http://dx.doi.org/10.2135/cropsci1983.0011183X002300030019

Kranz WL, Elmore RW, Specht JE. 1998. Irrigating soybean. University of Nebraska-lincoln extension educational programs,

Liu FM, Anderse N, Jensen CR. 2003. Loss of pod set caused by drought stress is associated with water status and aba content of reproductive structures in soybean. Functional Plant Biology **30,** 271-280. http://dx.doi.org/10.1071/FP02185

Mollasadeghi V, Valizadeh M, Shahryariand RA, Imani A. 2011. Evaluation of end drought tolerance of 12 wheat genotypes by stress in dices. Middle-East Journal of Scientific Research **7(2),** 241-247.

Moustafa MA. Boersma L, Kronstad WE. 1996. Response of four spring wheat cultivars to drought stress. Crop Science **36,** 982-986. http://dx.doi.org/10.2135/cropsci1996.0011183X003600040027x

Pandey RK, Herrera WAT, Pendleton JW. 1984. Drought response of grain legumes under irrigation gradient: III. Plant growth. Agronomy Journal **76,** 557-560, http://dx.doi.org/10.2134/agronj1984.00021962007600040010x

Pour Aboughadareh AR, Naghavi MR, Khalili M. 2013. Water deficit stress tolerance in some of barley genotypes and landraces under field conditions. Notulae Scientia Biologicae **5(2),** 249-255,

Roy-Macauley H, Zuily-Fodil H, Kidric Y, Pham-Thi M, Silva JV. 1992. Effect of drought stress on proteolytic activities in phaseolus and vigna leaves from sensitive and resistant plants. Physiologia Plantrum **85(1),** 90-96. http://dx.doi.org/10.1111/j.1399-3054.1992.tb05268.x

Silvieira JAG, Costa RCI, Viefgas RA, Olive-Ina JTA. Figueiredo MVB. 2003. N-compound accumulation and carbohydrate shortage on n2 fixation in drought stressed and rewatered cowpea plants. Spanish Journal of Agricultural Research **1(3),** 65-75,

Sionit N, Kramer PJ. 1977. Effect of water stress during different stages of growth of soybean. Agronomy Journal **69,** 274-278. http://dx.doi.org/10.2134/agronj1977.00021962006900020018x

Sori J, Dehghani H, Sabaghpor SH. 2005. Study of genotypes of chickpea in water stress condition. Iranian Journal of Agricultural Sciences **6,** 1517-1527, http://www.journals.ut.ac.ir (not available DOI number)

Van Heerden PDR, Kruger GHJ. 2002. Separately and simultaneously induced dark chilling and drought stress effects on photosynthesis proline accumulation and antioxidant metabolism in soybean. Journal of Plant Physiology **159(10),** 1077-1086. http://dx.doi.org/10.1046/j.1365-3040.2003.00966.x

Vendruscolo EC, Schuster I, Pilefggi MC, Scapim A, Molinari HBC, Marur CJ, Vieira LGE. 2007. Stress-induced synthesis of proline confers tolerance to water deficit in transgenic wheat. Journal Plant Physiology **164(10),** 1367-1376. http://dx.doi.org/10.1016/j.jplph.2007.05.001