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RESPONSE OF EARLY AND LATE MATURING SOYBEAN TO DROUGHT STRESS

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ABSTRACT

One of the most important tolerance mechanisms to drought stress in plants is drought escape. Therefore, in order to assess responses of soybean cultivars differential maturity periods of soybean to drought stress, a experiment was conducted in field at Research Station of Islamic Azad University, Kermanshah province, Iran. At the end of growth season, ten plants were selected randomly from each plot then their yield and yield components were measured. Results showed that soybean yield at water stress are dependent largely to maturity group. Also, all of the evaluated traits were reduced remarkably by drought stress. Regular irrigation had significantly increased soybean production in both early and late maturity groups. In this study, late maturity group is the most sensitive to water stress compared to early maturity group.

Key word: Drought stress, early maturity group, late maturity group, soybean, tolerance mechanisms

INTRODUCTION

Drought resistance in agricultural sense refers to the ability of a crop plant to give its economic produce with limited available water. Growth, development and yield of soybean is reduced with the occurrence of water stress during growing season and knowledge of the responses and resistance mechanisms of soybean to water stress may help to yield improvement. One of the wide spread drought tolerance mechanisms in plants is drought escape (short duration and/or complete life cycle before drought). In this way, plants with shortening the growth cycle or the development of phonological plasticity, which enables to mature before soil water, becomes limiting or by extending the period of flowering and reproductive phases to escape water deficits (Levitt, 1980; Turner, 1986). Drought escape is usually imparted through the combination of genotype maturity and planting date. Decrease in during of vegetative and reproductive growth stages in plant occurring when that Plants subjected by drought stress. The response of soybean to water stress is dependent on the determinate and indeterminate cultivar (Kadhem *et al*., 1985), maturity group (early or late maturity) (Abayomi, 2008) and the timing and the intensity of the water stress (Ashley and Etheridge, 1978; Korte *et al*., 1983; Kobraee and Shamsi, 2011; Kobraee *et al.*, 2011). In Western parts of Iran, soybean producers had sown during or Mid-May. Our previous studies were shown that soybean cultivars maturity groups III and IV are suitable for planting in western parts of Iran such as Kermanshah climatic conditions. This often results in avoidance of high temperature in Mid-summer and late season water deficits. Late maturity of soybean cultivars and/or delay in sowing, which results in coincidence of pod set and seed maturation of soybean, Increased flower and pod abortion, has been shown to be associated with decreases soybean yield. Such conditions commonly occur late of July and during August when late-maturity groups of soybean cultivars is flowering and pod set stages. Therefore, soybean yield and quality affected by water deficit or irrigation holding, severely. Thus, objects of this study are assessment responses early-maturity of soybean cultivars such as three and four maturity groups of soybean to drought stress and evaluate how high-yielding Kermanshah soybeans respond to withholding irrigation.

MATERIALS AND METHODS

The experiment was conducted in field conditions at research station of Islamic Azad University, Kermanshah province, Iran (($34^0 23^{'}$ N, $47^0 8^{'}$ E; 1351 m elevation). Eight soybean cultivars with following characteristics (Table 1) were sown on 20 May 2009.

Two separate experiments (stress site and normal site for each maturity group) were performed based on randomized complete block design with three replications. Inoculation of seeds with appropriate strain of *Bradyrhizobium japonicum* was carried out. In the normal site, irrigation was carried regularly when necessary to avoid water deficits, but in stress site, the plants were exposed to the drought stress by withholding irrigation at V_4, R_1 and R_3 growth stages. Phonological stages were defined according to Fehr and Caviness, (1977). At the end of growth season, ten plants were selected randomly from each plot then yield and yield components (number of node/plant, number of sub branch, number of pod/plant, number of seed/plant and 100-seed weight) were measured. For measure of pod, seed and total dry weight samples was dried at 70^{0c} and 48 hours. To calculate final yield, two middle rows of each plot were completely harvested considering the sides. Weight 13% deduction of moisture, grain dry weight was calculated and considered as economic yield. To determine biological yield, total plant dry weight was employed as biological yield, Harvest index was obtained by dividing economic yield by biological yield multiplied by 100. Data for evaluated traits were statistically analyzed using a standard analysis of Variance technique based on randomized complete block design using the MSTATC software. Means were separated by the Duncan's Multiple Range Test at 5 percent probability level.

Table 1. Soybean cultivars characteristics.

Cultivars name		Maturity group	Hilum color	Color of hairs of main stem	Flower color	Plant growth type
V1	Clark	IV	Black	Tawny	violet	Indeterminate
V2	Hobbit	III	Black	Tawny	violet	Indeterminate
V3	Pershing	IV	Dark Brown	Grey	White	Determinate
V4	Williams	III	Black	Tawny	White	Indeterminate
V5	Hood	IV	Light Brown	Grey	violet	Determinate
V6	DPX	IV	Black	Tawny	violet	Semi-determinate
V7	M7*	III	Black	Tawny	violet	Indeterminate
V8	M9**	III	Black	Tawny	violet	Indeterminate

*, ** - Mutants of Clark

Soil samples were collected from experimental area at 0-30 cm depth. The results of soil analysis were shown in Table 2.

Table 2. The results of soil analysis.

Soil properties	value
Soil texture	Silty clay
Organic matter (%)	2.2
pH	7.1
Electrical conductivity (dsm^{-1})	0.96
N (%)	0.15
P (ppm)	7.3
K (ppm)	515
Silt (%)	50.0
Sand (%)	8.6
Clay (%)	41.4

RESULTS AND DISCUSSION

The results of analysis of variance for evaluated traits at soybean cultivars belonged to MGIII in normal and stress sites were shown in Table 3. Based on results, there are not differences between cultivars concerning number of sub branch, pod dry weight per plant in normal and stress sites and biological yield, harvest index, seed dry weight per plant and total dry weight in normal site. While, number of pod per plant, number of seed per plant in normal and stress sites and number of node per plant in normal site and 100-seed weight per plant, seed yield, harvest index and total dry weight in stress site were affected by cultivar effects, and there were significant differences between cultivars ($P<0.01$). Statistical analysis for soybean cultivars (MG IV) showed that except number of sub branch, 100-seed weight per plant that unaffected by cultivar effect, there were significant differences

Table 3. Analysis of variance of evaluated traits in soybean (maturity group III) in normal and stress sites

Source of variation	df	MS: Number of node per plant		Number of sub branch		Number of pod per plant		Number of seed per plant		100-seed weight per plant		Seed yield	
		N	S	N	S	N	S	N	S	N	S	N	S
Block	2	2.40	0.03	0.08	0.07	2.40	1.89	4.44	0.77	0.11	0.12	9579.82	18644.55
Soybean cultivars (maturity group III)	3	80.43**	17.93*	0.34^{ns}	0.14^{ns}	74.46**	50.05**	173.75**	223.97**	1.91*	1.61**	628024.41*	1217890.68**
Error	6	3.96	2.37	0.09	0.13	1.65	0.16	11.34	1.92	0.45	0.07	68547.66	17069.41
Coefficient of variation (%)	-	10.60	11.11	12.01	14.85	9.26	8.28	7.83	10.15	9.55	7.07	12.22	9.20

Source of variation	df	Ms: Biological yield		Harvest index		Pod dry weight per plant		Seed dry weight per plant		Total dry weight	
		N	S	N	S	N	S	N	S	N	S
Block	2	396624.75	8919.39	4.33	0.26	0.09	0.11	1.74	0.11	0.30	0.03
Soybean cultivars (maturity group III)	3	545007.94^{ns}	327499.06*	6.14^{ns}	5.93**	0.34^{ns}	0.05^{ns}	3.22^{ns}	7.01**	10.85^{ns}	24.59**
Error	6	204490.42	34525.68	1.34	0.54	0.20	0.02	0.78	0.11	4.87	0.82
Coefficient of variation (%)	-	10.99	9.50	6.75	9.32	8.23	9.39	8.69	9.96	8.47	9.13

-ns, * and **: Non significant, significant at 5 and 1% levels of probability, respectively.
-N: normal condition S: stress condition

Table 4. Analysis of variance of evaluated traits in soybean (maturity group IV) in normal and stress sites

Source of variation	df	MS: Number of node per plant		Number of sub branch		Number of pod per plant		Number of seed per plant		100-seed weight per plant		Seed yield	
		N	S	N	S	N	S	N	S	N	S	N	S
Block	2	1.63	2.90	0.11	0.09	1.63	1.49	0.50	3.53	0.41	0.15	4658.27	58140.62
Soybean cultivars (maturity group IV)	3	29.95^{**}	43.34^{**}	0.91^{ns}	0.15^{ns}	85.86^{**}	30.73^{**}	216.73^{**}	257.43^{**}	0.48^{ns}	0.66^{ns}	1043828.00^{**}	906858.96^{**}
Error	6	1.09	0.88	0.28	0.19	0.83	0.16	6.01	2.23	0.76	0.46	70847.99	29278.70
Coefficient of variation (%)	-	9.57	8.94	10.86	10.43	8.97	10.06	6.07	7.83	7.98	6.38	9.40	10.78

Source of variation	df	Ms: Biological yield		Harvest index		Pod dry weight per plant		Seed dry weight per plant		Total dry weight	
		N	S	N	S	N	S	N	S	N	S
Block	2	90452.72	58616.81	1.01	1.71	0.16	0.24	1.13	0.04	3.50	0.80
Soybean cultivars (maturity group IV)	3	2841074.29^{**}	802799.27^{**}	10.64^{ns}	9.92^{**}	1.77^{**}	0.85^{**}	13.69^{**}	3.39^{**}	24.65^{ns}	13.49^{*}
Error	6	30145.23	51965.69	2.89	0.81	0.07	0.05	0.14	0.06	7.68	1.69
Coefficient of variation (%)	-	10.47	9.61	9.08	7.17	8.59	9.65	10.85	9.80	9.47	9.40

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

-N: normal condition S: stress condition

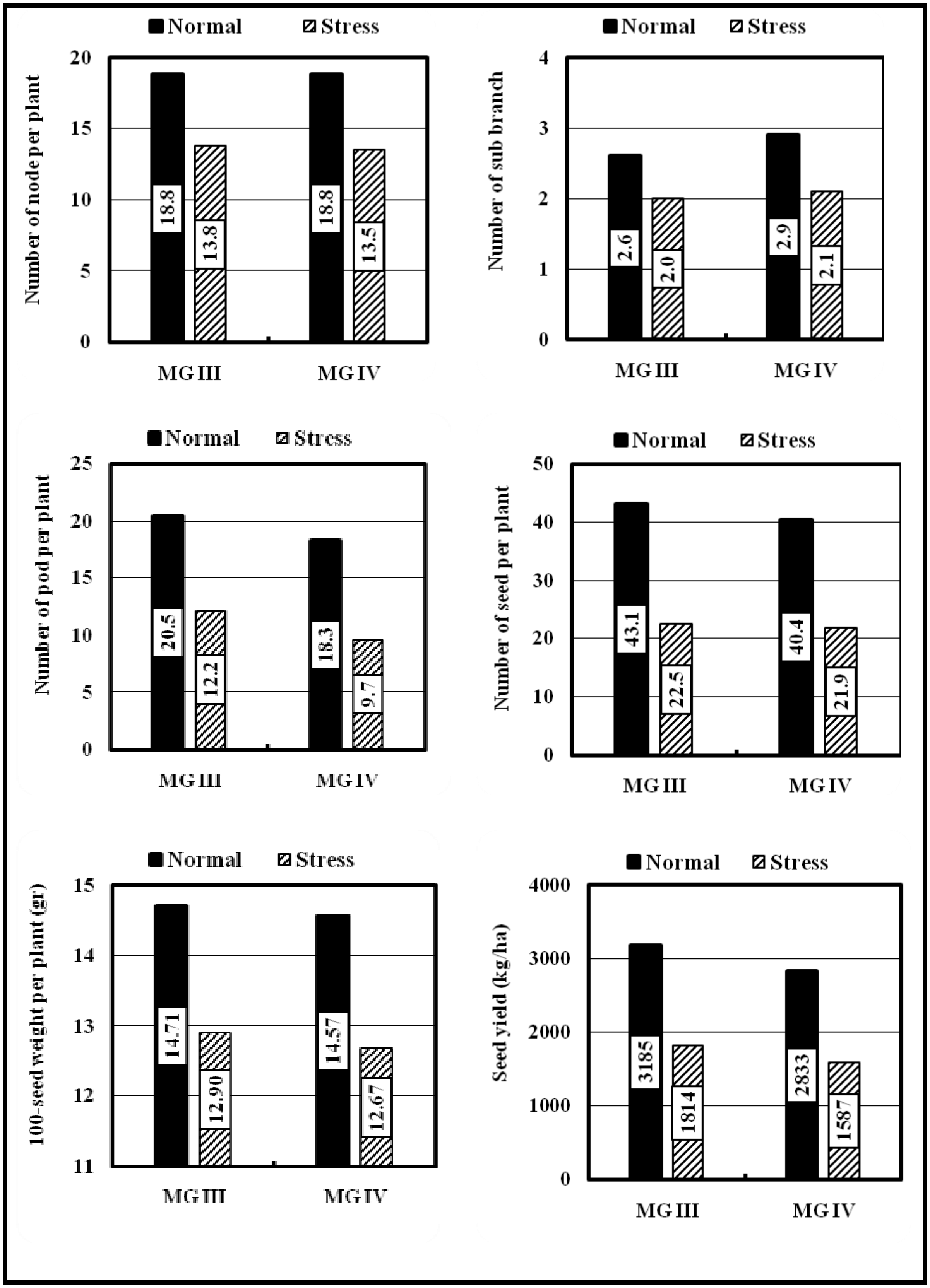
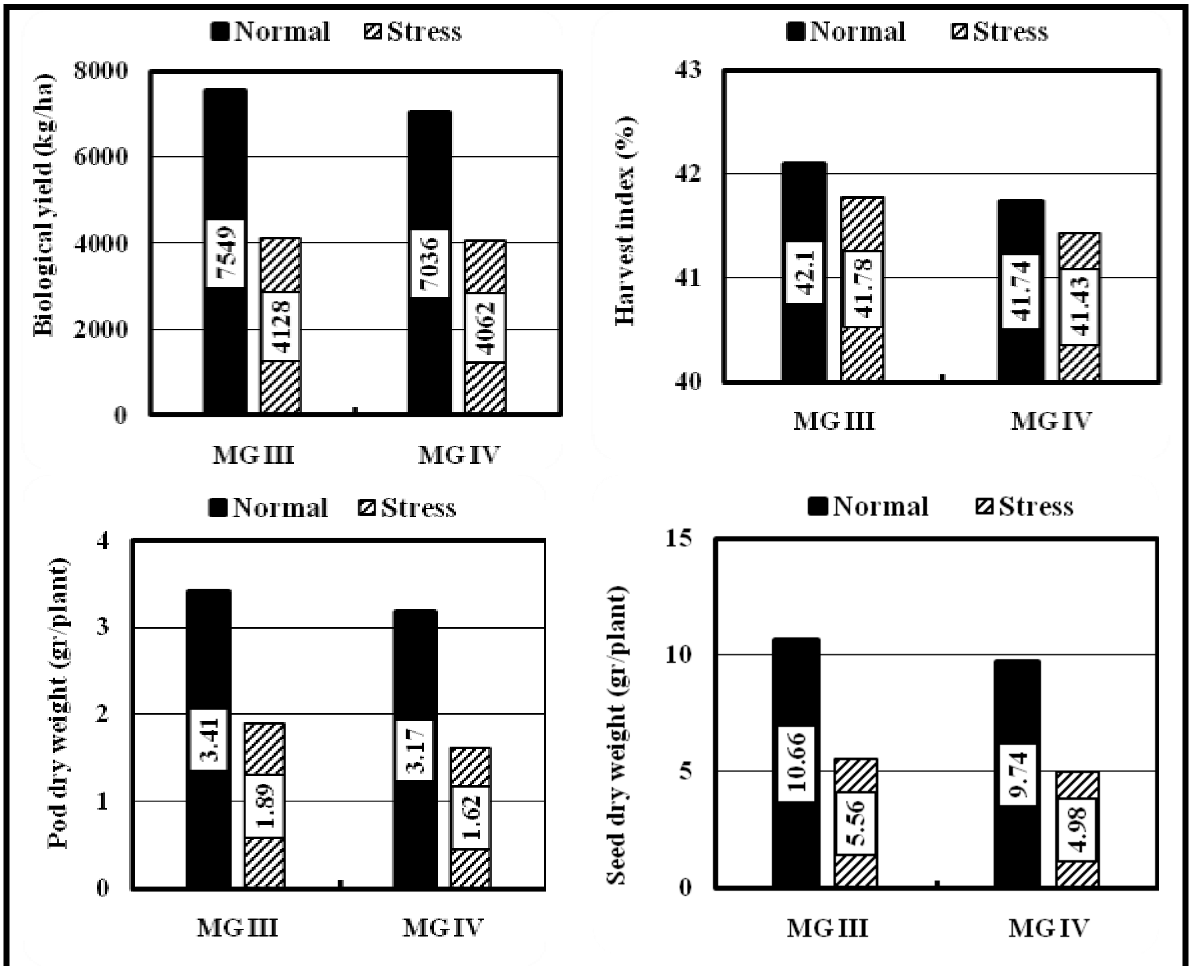
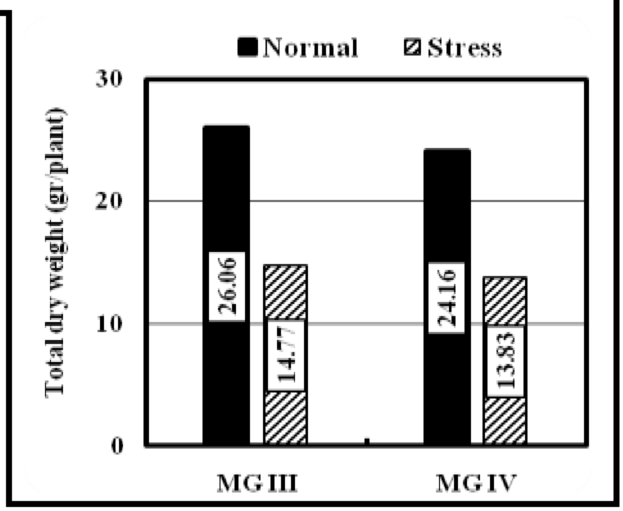


Fig. 1. Comparison of evaluated traits between two maturity groups of soybean (III and IV) affected by drought stress.





Continue of Figure 1. Comparison of evaluated traits between two maturity groups of soybean (III and IV) affected by drought stress.

between cultivars concerning the other evaluated traits (Table 4). Effects of drought stress on evaluated traits in soybean cultivars (MG III and MG IV) were shown in Figure 1. Generally, all of evaluated traits were reduced remarkable by drought stress. Regular irrigation has been shown to significantly increase production of soybean (Sionit and Kramer, 1977; Ashley and Ethridge, 1978; Mustapha, 2005), chickpea (Zhang *et al*., 2000; Anwar *et al*., 2003), barley (Campbell et al., 1980), cowpea (Abayomi, 1992; Aderolu, 2000), wheat (Blum *et al*., 1989) and safflower (Ibrahim *et al*., 1991; Ozturk *et al*., 2008). The average number of node per plant in soybean cultivars MG III and MGIV at normal site are 18.8 that in stress conditions reduced. Number of pod per plant declined in stress conditions compared regular irrigated plant. Soybean cultivars MG III had high pod number per plant and less decreased withholding irrigation. The similar results were observed for number of seed per plant. Stress conditions had the large effects on reducing 100-seed weight per plant. A decrease in this trait was observed in both maturity groups of soybean, equally. Seed yield affected by water deficit and reduced, sharply. Therefore, seed yield of soybean cultivars MG III in regular irrigated plants declined from 3185 kg/ha to 1814 kg/ha in stressed plants. While, seed yield in soybean cultivars MG IV in normal and stress sites were recorded 2833 and 1587 kg/ha, respectively. Superiority of soybean cultivars belonged to MG III was observed in other measured traits such as biological yield, harvest index, pod, seed and total dry weight (Fig. 1). Finally, in this experiment soybean cultivars MG III appeared better than the soybean cultivars MG IV. Boyer and Johnson, (1980) stated that only drought stress occurring at flowering stage decreased seed yield in early maturity group, and stress conditions at vegetative and reproductive stages reduced seed yield in the late maturity group. Therefore, late maturity group is most sensitive to water stress compared to early maturity group. In addition, pod set stage in late maturity group and flowering stage in early maturity group had the most sensitive to drought stress (Abayomi, 2008). The mean pod, seed and total dry matter production at harvest time increased significantly with full irrigation. Fully irrigated plants produced 43% more total dry weight than stressed plants. This value for pod dry weight for ranged between 45-49 percents. In addition, seed dry weight production in stressed plants reduced average 48-49 percent less than the regular irrigated plants. Decrease in dry matter production in stressed plant emphasized by Meckel *et al*., (1984). Nevertheless, Full irrigation in normal site significantly increased total dry weight production to 26.06 g/plant (Fig. 1). Harvest index reduced by drought stress and there are significant differences between cultivars in both soybean maturity groups in stress site. Marked decline in soybean biological yield in different maturity groups were observed between 42-45 percent. Regular irrigation increased seed yield by 43-44 % in MG III and MG IV, respectively. Seed yield in normal site in MG III and MG IV were recorded 3185 and 2833 kg/ha, respectively. In evaluated traits, harvest index had the most stable among cultivars and maturity groups. Results of this study showed that soybean yield at water stress conditions are dependent largely to maturity group.

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