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Effects of drought stress on yield and yield components of soybean

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ABSTRACT

In order to evaluate effects of drought stress on yield and yield components of soybean (Glycine max L.), an experiment was conducted in the research field of the Islamic Azad University of Kermanshah, Iran at 2009. Responses of eight soybean cultivars at two separate experiments (normal and stress sites) were investigated based on randomized complete block design with three replications. The results were shown that except number of sub branch in stress site and 100-seed weight per plant in normal site other traits affected by cultivar effect. Cultivars had significantly differences in number of sub branch and 100-seed weight in main stem in normal site at 5% levels and other traits in both trials at 1% levels. Means comparison was shown that Williams cultivar had the highest number of node/plant, number of pod/main stem, pod/sub stem and pod/plant in normal and stress conditions. In normal site, Clark cultivar had the highest value of number of sub branch, and superiority to other cultivars. The highest and lowest number of seed/main stem, seed/sub stem and seed/plant was observed in Williams and Hood cultivars, respectively. Decrease in seed yield in stress site compared normal conditions recorded about 43-44%.

Keyword: pod, seed, soybean, stress conditions, yield component.

INTRODUCTION

Soybean production has been increased from about 26 to 223 million tons due to increases in harvest area and yield [6]. From 1961 onwards, soybean yield increased an average rate of 22.76kg/ha/year, increasing from 1129kg/ha in 1961 to 2243 kg/ha in 2009 (Fig 1). Trend of soybean yield at last year's is disharmony with world population growth. Agronomists for producing further may focus on plant adaptation by phonological adjustment or resistance to biotic and abiotic stress. Therefore, Knowledge about plant responses to these stresses is very important for acquisition cultivars with high yield potential. Drought stress decreases soybean yield by decline in yield components. Stage of plant growth and duration of drought stress are important for the degree of the impact on growth and final yield in soybean. For example, [3, 5] declared that one of the most sensitive growth stages in soybean to drought stress are pod set and seed filling period that had large effects on soybean yield. Also, [15] stated that occurrence of water deficit and high temperature at early of flowering to maturity shortening seed filling period and reduces grain weight. Soybean yield affected by pod and seed number per plant and these traits are the most important yield components of soybean [12]. In previous research, soybean yield divided into several components such as number of node per plant, pod per node, seed per pod and seed weight [2, 9]**.** In the more research seed number introduced as an important component which soybean yield is dependent to it [5, 8]. There is a differential response in yield components to changes in environmental conditions. Thus, the main objective in our experiment is determined effects of drought stress on yield components and final yield of soybean in climatic conditions of Kermanshah.

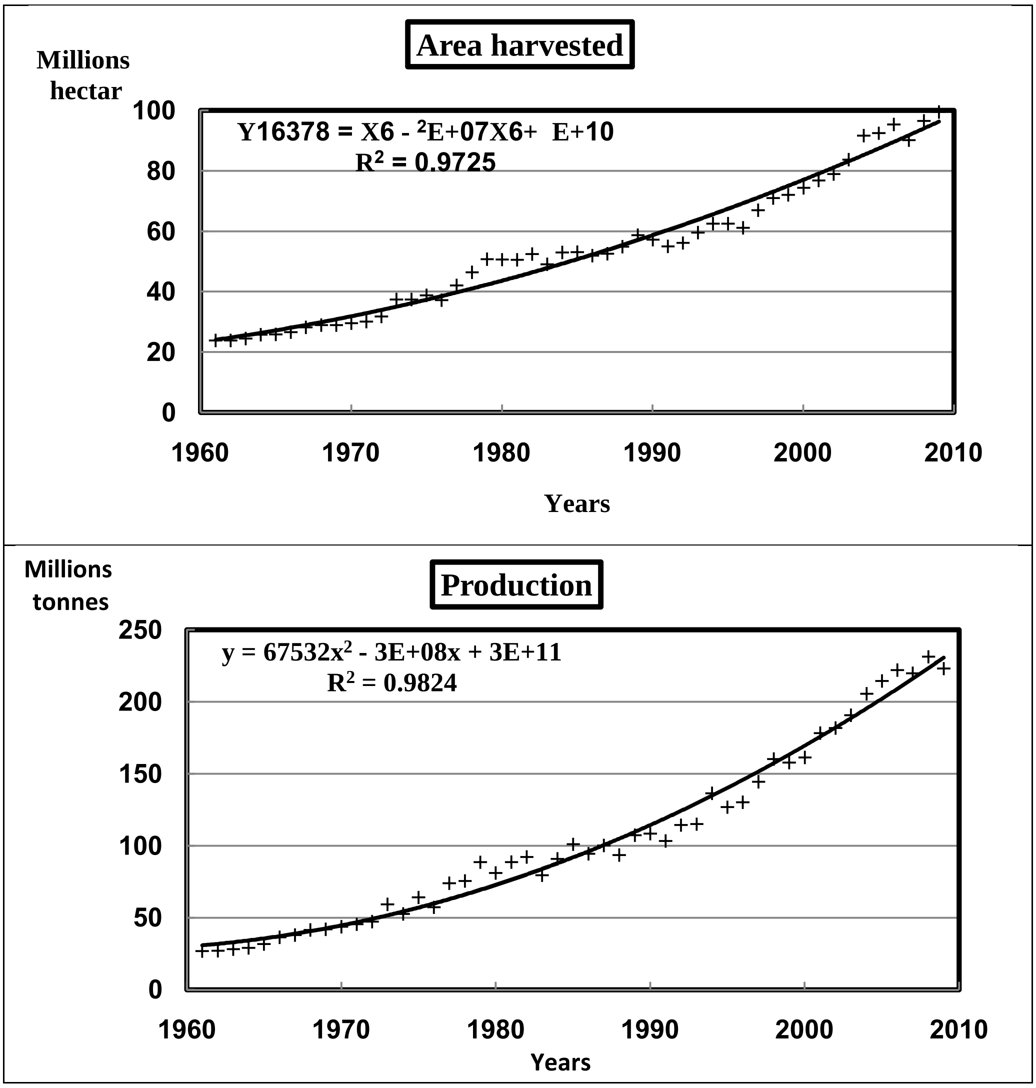
MATERIALS AND METHODS

Two separate experiments (stress site and normal site) were performed based on randomized complete block design with three replications in the research field of the Islamic Azad University of Kermanshah province, Iran ($34^0 23^'$ N, $47^0 8^'$ E; 1351 m elevation). Soybean seeds (V_1: Clark, V_2: hobbit, V_3: pershing, V_4: Williams, V_5: Goorgan-3 (registered name: Hood), V_6: DPX, V_7: M_7 and V_8: M_9) were sown during 2009 growing season. Seeds were inoculated with Brady*Rhizobium japonicum* and sown at a high-planting rate the field. When the unifoliate leaves were expanded, the plots were hand-thinned to obtain a uniform plant population of 33 plants per m^2. 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 [7]. At the end of growth season, ten plants were selected randomly from each plot and yield component such as number of sub branch, number of node; pod and seed per plant and seed weight were measured. 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. 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.

RESULTS AND DISCUSSION

The results of analysis of variance show that there are significant differences among cultivars in yield and yield components (Table1). Except number of sub branch in stress site and 100-seed weight per plant in normal site other traits affected by cultivar effect. Cultivars had significantly differences in number of sub branch and 100-seed weight in main stem in normal site at 5% levels ($P<0.05$) and other traits in both trials at 1% levels ($P<0.01$). Means comparison (Table 2) was shown that Williams cultivar with 26.3 and 17.4 node per plant had the highest number of node per plant in normal and stress conditions, respectively. In addition, the highest number of pod per main stem, sub stem and plant belonged to this cultivar (Table 2). Under stress conditions, number of node per plant had high correlation with number of pod per plant ($r=0.91^{**}$) and number of seed per plant ($r=0.92^{**}$) (Table 3). In normal site Clark cultivar had the highest value of number of sub branch, and superiority to other cultivars. The highest and lowest number of seed per main stem, sub stem and plant was observed in Williams and Hood cultivars, respectively. The results of pearson correlation in stress site was shown that there were positive and significantly correlation between number of seed per plant with number of pod per sub stem ($r=0.93^{**}$) and number of seed per plant ($r=0.93^{**}$) (Table 3). After Williams, DPX cultivar was appeared better than the other cultivars and had the highest 100-seed weight per main stem in stress site and 100-seed weight in sub stem in both conditions. [13] Stated that seed weight is the resulted of the rate and duration of effective seed filling period, that drought decreases both there.

Seed weight decreases in stress conditions and this result was agrees to previous studies [10, 11, 17]. [14] Emphasized that drought stress at reproductive growth stages disrupted photosynthesis and remobilization in plants, which can caused reduction in the number and weight of grains. The highest seed yield in normal and stress site belonged to Williams. Generally, the results was shown that drought stress reduced yield and yield components in all of cultivars. Decrease in seed yield in stress site compared normal conditions arranged 43-44% (data not shown). [1, 4, 16] Reported that soybean yield decreases average 32-60 percent due to water deficit in flowering, pod set and seed forming stages. There are positive and significant differences between number of node per plant with number of pod per main stem (r=0.84**), number of pod per sub stem (r=0.88**), number of pod per plant (r=0.81**), number of seed per main stem (r=0.85**) and number of seed per plant (r=0.89**) (Table 4).



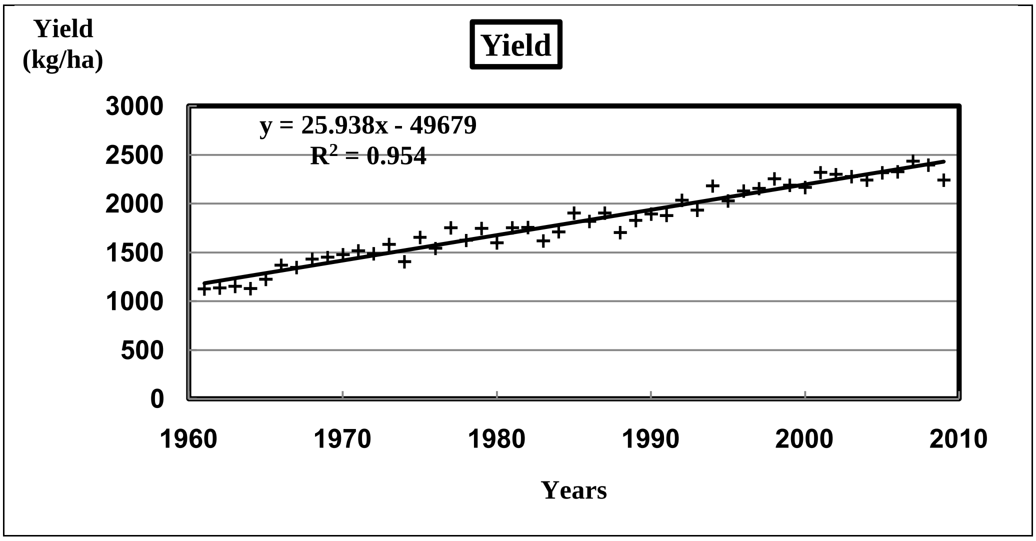


Figure 1. Harvest area, production and grain yield of soybean in world from 1961 to 2009 (Fao Statistic Deviation, 2011)

Table 1. Analysis of variance of grain yield and yield components of soybean in normal and stress sites

Source of variation	df	MS											
		Number of node per plant		Number of sub branch		Number of pod per main stem		Number of pod per sub stem		Number of pod per plant		Number of seed per main stem	
		N	S	N	S	N	S	N	S	N	S	N	S
Block	2	1.39	1.16	0.01	0.16	0.02	0.14	0.65	0.31	3.57	0.38	2.96	0.07
Cultivar	7	47.30^{**}	26.37^{**}	0.64^{*}	0.15^{ns}	20.95^{**}	14.46^{**}	6.96^{**}	5.03^{**}	72.92^{**}	39.76^{**}	45.79^{**}	65.19^{**}
Error	14	2.54	1.64	0.19	0.14	0.47	0.33	0.25	0.22	1.13	0.56	1.94	0.40
Coefficient of variation (%)	-	8.69	9.37	15.56	13.91	5.32	7.10	6.35	10.45	5.47	7.86	6.97	9.01

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

Continue of table 1. Analysis of variance of grain yield and yield components of soybean in normal and stress sites

Source of variation	df	MS											
		Number of seed per sub stem		Number of seed per plant		100-seed weight per main stem		100-seed weight per sub stem		100-seed weight per plant		Seed yield	
		N	S	N	S	N	S	N	S	N	S	N	S
Block	2	0.16	0.32	2.86	0.50	0.09	0.50	0.38	0.06	0.09	0.03	13797.2	6717.5
Cultivar	7	20.40^{**}	5.50^{**}	173.37^{**}	206.70^{**}	1.04^{*}	3.39^{**}	2.72^{**}	1.67^{**}	1.03^{ns}	1.02^{**}	822892.7^{**}	954979.2^{**}
Error	14	0.74	0.26	8.45	2.32	0.37	0.53	0.28	0.20	0.58	0.26	59803.9	29873.1
Coefficient of variation (%)	-	6.52	9.94	7.95	3.86	5.48	9.69	6.35	7.38	5.19	8.01	8.13	10.16

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

Table 2. Means comparison of grain yield and yield components of soybean in normal and stress sites

Cultivar	Means											
	Number of node per plant		Number of sub branch		Number of pod per main stem		Number of pod per sub stem		Number of pod per plant		Number of seed per main stem	
	N	S	N	S	N	S	N	S	N	S	N	S
Clark	21.2 b	14.1 b	3.5 a	2.4 a	14.1 b	8.7 bc	8.7 b	5.3 a	20.4 c	11.3 bc	29.6 b	14.3 cd
Hobbit	17.5 c	11.9 b	2.5 bc	1.7 a	13.6 bc	7.3 de	7.7 c	4.1 b	19.1 cd	10.0 c	27.9 bcd	13.7 d
Pershing	17.5 c	13.9 b	2.3 c	1.9 a	12.7cd	6.8 e	7.1 c	4.3 b	15.9 e	10.2 c	29.1 bc	13.9 cd
Williams	26.3 a	17.4 a	3.1 abc	2.2 a	17.6 a	11.7 a	9.9 a	6.0 a	27.9 a	18.3 a	32.4 a	24.1 a
Hood	14.9 c	8.4 c	2.7 abc	2.1 a	8.2 e	4.1 f	4.9 d	2.2 c	12.3 f	5.1 d	20.2 e	10.1 e
DPX	21.5 b	17.6 a	3.3 ab	2.3 a	13.2 bc	9.4 b	9.0 b	6.1 a	24.6 b	12.3 b	32.1 a	21.7 b
M7	16.8 c	12.7 b	2.4 c	2.0 a	11.7 d	8.7 bc	7.1 c	4.1 b	17.8 de	10.2 c	25.8 d	14.9 c
M9	14.5 c	13.4 b	2.4 c	2.1 a	11.8 d	8.3 cd	7.3 c	3.7 b	17.3 de	10.2 c	26.9 cd	13.6 d

-Similar letters in each column shows non-significant difference according to Duncan's Multiple Range Test at 5% level
-N: normal condition S: stress condition

Continue of table 2. Means comparison of grain yield and yield components of soybean in normal and stress sites

Cultivar	Means											
	Number of seed per sub stem		Number of seed per plant		100-seed weight per main stem (gr)		100-seed weight per sub stem (gr)		100-seed weight per plant (gr)		Seed yield (kg/ha)	
	N	S	N	S	N	S	N	S	N	S	N	S
Clark	14.5 bc	6.2 b	46.4 b	27.2 c	14.62 ab	12.82 bc	14.69 b	12.65 d	14.71 ab	13.16 ab	2750 b	1435 cd
Hobbit	13.2 cd	5.1 c	40.8 c	16.1 e	13.75 b	11.18 d	13.35 c	12.17 d	13.82 b	12.07 c	2712 b	1265 de
Pershing	13.5bcd	5.1 c	37.6 c	19.2 d	14.72 ab	13.07 abc	13.86 bc	12.47 d	14.75 ab	12.73	2873 b	1514 cd

Williams	16.7 a	7.2 a	54.3 a	35.2 a	15.60 a	14.11 ab	16.01 a	13.71 ab	15.70 a	bc 13.85 a	3611 a	2737 a
Hood	7.8 e	2.5 d	29.6 d	10.1 f	13.92 b	11.71 cd	14.04 bc	12.82 cd	13.98 b	12.03 c	2135 c	1046 e
DPX	14.9 b	5.4 bc	47.9 b	31.0 b	14.89 ab	14.25 a	15.93 a	14.36 a	14.86 ab	12.75 bc	3573 a	2356 b
M7	12.9 cd	5.0 c	37.9 c	20.7 d	14.84 ab	12.71 c	14.31 bc	13.5 bc	14.81 ab	12.78 bc	3132 b	1723 c
M9	12.0 d	4.5 c	39.1 c	18.2 de	14.31 b	12.35 cd	14.27 bc	13.61abc	14.35 ab	12.91a bc	3086 b	1542 cd

-Similar letters in each column shows non-significant difference according to Duncan's Multiple Range Test at 5% level
-N: normal condition S: stress condition

Table 3. pearson correlation between grain yield and yield components in normal site

	NN	NSS	NPMS	NPSS	NPP	NSMS	NSSS	NSP	SWMS	SWSS	SWP	SY
NN	1.00											
NSS	0.72^{**}	1.00										
NPMS	0.87^{**}	0.28^{ns}	1.00									
NPSS	0.87^{**}	0.49^{*}	0.86^{**}	1.00								
NPP	0.91^{**}	0.52^{**}	0.84^{**}	0.91^{**}	1.00							
NSMS	0.79^{**}	0.40^{ns}	0.82^{**}	0.89^{**}	0.83^{**}	1.00						
NSSS	0.83^{**}	0.30^{ns}	0.90^{**}	0.90^{**}	0.84^{**}	0.86^{**}	1.00					
NSP	0.92^{**}	0.58^{**}	0.83^{**}	0.93^{**}	0.93^{**}	0.82^{**}	0.87^{**}	1.00				
SWMS	0.78^{**}	0.34^{ns}	0.52^{**}	0.51^{**}	0.51^{**}	0.42^{*}	0.56^{**}	0.50^{*}	1.00			
SWSS	0.80^{**}	0.54^{**}	0.48^{*}	0.56^{**}	0.70^{**}	0.49^{*}	0.54^{**}	0.67^{**}	0.71^{**}	1.00		
SWP	0.80^{**}	0.13^{ns}	0.49^{*}	0.53^{**}	0.51^{**}	0.34^{ns}	0.55^{**}	0.52^{**}	0.42^{*}	0.49^{*}	1.00	
SY	0.71^{**}	0.27^{ns}	0.67^{**}	0.76^{**}	0.79^{**}	0.77^{**}	0.74^{**}	0.75^{**}	0.60^{**}	0.66^{**}	0.45^{*}	1.00

*-ns, * and **: Non significant, significant at 5 and 1% levels of probability, respectively.*
-NN: number of node per plant, NSS: number of sub branch, NPMS: number of pod per main stem, NPSS: number of pod per sub stem, NPP: number of pod per plant, NSMS: number of seed per main stem, NSSS: number of seed per sub stem, NSP: number of seed per plant, SWMS: 100-seed weight per main stem, SWSS: 100-seed weight per sub stem, SWP: 100-seed weight per plant and SY: seed yield.

Table 4. Pearson correlation between grain yield and yield components in stress site

	NN	NSS	NPMS	NPSS	NPP	NSMS	NSSS	NSP	SWMS	SWSS	SWP	SY
NN	1.00											
NSS	0.11^{ns}	1.00										
NPMS	0.84^{**}	0.12^{ns}	1.00									
NPSS	0.88^{**}	0.24^{ns}	0.82^{**}	1.00								
NPP	0.81^{**}	0.17^{ns}	0.91^{**}	0.79^{**}	1.00							
NSMS	0.85^{**}	0.25^{ns}	0.84^{**}	0.82^{**}	0.88^{**}	1.00						
NSSS	0.71^{**}	0.19^{ns}	0.80^{**}	0.81^{**}	0.89^{**}	0.71^{**}	1.00					
NSP	0.89^{**}	0.32^{ns}	0.89^{**}	0.92^{**}	0.87^{**}	0.90^{**}	0.81^{**}	1.00				
SWMS	0.71^{**}	0.35^{ns}	0.59^{**}	0.62^{**}	0.65^{**}	-0.72^{**}	0.57^{**}	0.73^{**}	1.00			
SWSS	0.56^{**}	0.20^{ns}	0.49^{*}	0.43^{*}	0.39^{ns}	0.61^{**}	0.18^{ns}	0.52^{**}	0.55^{**}	1.00		
SWP	0.65^{**}	0.10^{ns}	0.76^{**}	0.58^{**}	0.68^{**}	0.55^{**}	0.58^{**}	-0.72^{**}	0.50^{*}	0.34^{ns}	1.00	
SY	0.79^{**}	0.20^{ns}	0.84^{**}	0.76^{**}	0.82^{**}	0.94^{**}	0.64^{**}	0.88^{**}	0.68^{**}	0.62^{**}	0.69^{**}	1.00

*-ns, * and **: Non significant, significant at 5 and 1% levels of probability, respectively.*
-NN: number of node per plant, NSS: number of sub branch, NPMS: number of pod per main stem, NPSS: number of pod per sub stem, NPP: number of pod per plant, NSMS: number of seed per main stem, NSSS: number of seed per sub stem, NSP: number of seed per plant, SWMS: 100-seed weight per main stem, SWSS: 100-seed weight per sub stem, SWP: 100-seed weight per plant and SY: seed yield.

CONCLUSION

Based on results, soybean yield and yield components decreased when that drought stress occurred. Withholding irrigation reduced grain yield about 43-44% in stress site compared with normal irrigated plants. Among cultivars Williams and DPX are better than the other for cultivation in Kermanshah climatic conditions. In this study, these varieties are high yield potential in drought stress conditions and Hood cultivar is appeared weakness.

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REFERENCES

[1]- JM Andriani; FH Andrade; EE Suero; JL Dardanelli, *Agronomie*, **1991**, 11, 77-746.
[2]- JE Boared; Q Tan, *Crop Sci*, **1995**, 35, 846-851

[3]- D Desclaux; T-T Huynh; P Roumet, *Crop Sci*, **2000**, 40, 716-722.
[4]- PI De Souza; DB Egli; WP Bruening, *Agron J*, **1997**, 89, 807-812.
[5]- DB Egli; L Meckel; RE Philips; D Radelff; GE Legett, *Agron J*, **1983**, 75, 1027-1031.
[6]- FAO, 2011, Fao statistic deviation, *http://faostat.fao.org/default.aspx*, **2011**.
[7]- WR Fehr; CE Caviness, *Stages of soybean development*, Spec, Rep, 80, Iowa State Univ., Ames. **1977**.
[8]- S Kobraee; K Shamsi, *Ann Biol Res*, **2011**, 2 (4), 334-342.
[9]- S Kobraee; K Shamsi; B Rasekhi; S Kobraee, *African J Biotech*, **2010**, 9 (16), 2342-2348.
[10]- M Kokubun; S Shimada; M Takahashi, *Crop Sci*, **2001**, 4, 1517-1521.
[11]- W Lei; Z Tong; D Shengyan, *Acta Ecologica Sinica***, 2006**, 26 (7), 2073-2078.
[12]- X Liu; J Jin; SJ Herbert; Q Zhang; G Wang, *Field Crop Res*, **2005**, 93, 85-93.
[13]- NG Munier-Jolain; NM Munier-Jolain; R Roche; B Ney; C Duthion, *J. Exp. Bot*, **1998**, 49, 1963-1969.
[14]- RA Richards; AG Condon; GJ Rebetzke, *Application of physiology in wheat breeding*, Mexico, D. F. CIMMYT, **2001**, pp, 88-100.
[15]- C Royo; M Abaza; R Blanco; D Garcia; LF Moral, *Aust. J. Plant Physiol*, **2000**, 27, 1051-1059.
[16]- RD Vieira; DM Tekrony; DB Egli**,** *Crop Sci*, **1992**, 32, 471-475.
[17]- ME Westgate; CM Peterson, *J. Exp. Bot*, **1993**, 44, 109-117.