INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 3, p. 50-56, 2013

RESEARCH PAPER OPEN ACCESS

Effect of drought stress on yield and yield components of some sunflower recombinant inbred lines

Banaei-Asl Farzad[1], Toorchi Mahmoud[1*], Norouzi Majid[1], Shakiba Mohamad-reza[2]

[1]*Department of Plant Breeding and Biotechnology, University of Tabriz, Iran*
[2]*Department of Plant Eco-physiology, University of Tabriz, Iran*

Key words: Sunflower, drought, yield and yield component, recombinant inbred lines, principle component analysis.

doi: http://dx.doi.org/10.12692/ijb/3.3.50-56 Article published on March 28, 2013

Abstract

Nine sunflower inbred lines as listed in (table 3) were chosen for this study. The present work was planned to study effect of drought on yield and yield components of selected inbred lines of sunflower. The information will be important in developing sunflower cultivars tolerant to water stress. The experiment was conducted in a randomized complete block design (RCBD) under split plot arrangement with three replications. The main plots comprised of three treatments i.e. severe water stress, mild water stress and normal irrigation. In the normal condition, plants were watered daily throughout the cropping period, while in the mild and severe stress condition; water stresses was created from R4 and R6 stage, respectively. Highly significant differences observed between stress treatment for Head diameter and stem diameter. While for seed yield and 1000 seed weight exhibited significant differences. Mean squares of different traits under drought and normal irrigation conditions revealed highly significant differences between sunflower inbred lines for all the traits studied. B329, R56 and B147 were less affected under water stress conditions as compared to other lines for seed yield per plant and head diameter. Inbred line B343 for number of seed per plant and inbred line R50 for 1000 seed weight were less affected too. Inbred lines B329 and R56 proved more drought tolerant for stem diameter and plant height. Principle component analyses were done in all three treatments. There were two principle components in each PCA. Thefirst PC (PC1) had high positive correlation with all the traits studied except number of seed per plant. The second (PC2) mostly had high positive correlation with number of seed per plant. The lines B329, R56, B343, R50 and R26 had the least variance in these three treatments. In other word, they were drought tolerant in this experiment but only B329 and R56 had high performance compare with other lines.

---

* **Corresponding Author:** Toorchi Mahmoud ✉ mtoorchi@yahoo.com

Introduction

In natural environment plants are subjected to several stresses that adversely influence growth, metabolism, and yield. Biotic (insects, bacteria, fungi, and viruses) and abiotic (light, temperature, water availability, nutrients, and soil structure) factors affect the growth of higher plants. Among these, drought is a major abiotic factor that limits agricultural crop production (Reddy *et al.*, 2004).

Water stress is one the major limitations to crop yields worldwide, and possible global climate change scenarios suggest a future increase in the risk of drought (IPCC 2001). Breeding crop varieties for improved water use efficiency is, therefore, of great importance(Condon *et al.*, 2004). Photosynthesis in higher plants is known to decrease with the relative water content (RWC) and leaf water potential decreases (Lawlor and Cornic, 2002). Drought mainly limits photosynthesis through stomatal closure and through metabolic impairment (Lawson *et al.*, 2003). Drought stress can affect growth of plant organs, resulting in the alteration of the morphological features of the plants (French and Turner, 1991). Plants have different life strategies to cope drought stress, like drought avoidance and drought tolerance. The ability of plants to delay harmful decrease in the water potential of the protoplasm is considered as avoidance of desiccation. Desiccation tolerance means that plants have ability to maintain their normal functions even at low tissue water potentials. A wide diversity of drought tolerance mechanisms; both morphological and physiological have been developed in plants (Blum, 1996).

Although, sunflower has good potential for drought tolerance because of its well-developed root system, yet decrease in plant height, 100-seed weight, head diameter and seed yield per plant under water stress conditions has been observed (Attene and Porru, 1990). If drought resistant cultivars are developed, sunflower can be grown successfully in areas where water is a limiting factor. The plant breeders are continuously trying to improve sunflower yield through improvement of various plant characters (Pasda and Diepenbrock, 1990).

A crucial aspect in all studies dedicated to drought tolerance is the assessment of the degree of drought tolerance of different genotypes. In many studies the identification of tolerant and susceptible cultivars is based on few physiological measures related to drought response. The difficulty in identifying a physiological parameter as a reliable indicator of yield in dry conditions has suggested that yield performance over a range of environments should be used as the main indicator for drought tolerance (Voltas *et al.*, 2005). The present work was planned to study effect of drought on yield and yield components of selected inbred lines of sunflower to find favorable lines that will be usefulto produce high yielding tolerant hybrids in water stress condition.

Material and method

Plant material and experiment condition

Nine sunflower inbred lines as listed in (table 3) were chosen for this study. Experiment was conducted at the research farm in University of Tabriz (northwest of Iran) during growing season of 2010. Each genotype was sown in two rows of 3 m length and distance between rows of 60 cm. Two seeds of sunflower were planted in each hole by hand and thinned to single plant at seedling stage. The experiment was conducted in a randomized complete block design (RCBD) under split plot arrangement with three replications. The main plots comprised of three treatments i.e. severe water stress, mild water stress and normal irrigation. In the normal condition, plants were watered daily throughout the cropping period, while in the mild and severe stress condition; water stresses was created from R4 and R6 stage, respectively, to the end of physiological maturity by withholding irrigation and preventing rainwater using a rainout shelter.

Traits studied

Data were recorded from five randomly taken plants per replicate of each inbred line for plant height, head diameter, 1000 seed weight, yield per plant and stem diameter.

Statistical methods

Multivariate statistical analysis as principle component analysis, biplot display, and discriminant analysis were performed using the SPSS software.

Result and discussion

Mean squares of different traits under drought and normal irrigation conditions (Table 1) revealed highly significant differences between stress treatment for Head diameter and stem diameter. While for seed yield and 1000 seed weight exhibited significant differences. And non-significant differences were recorded for number of seed per plant. The differences among the lines were highly significant for all the traits studied. Line × treatment interaction was non-significant for all the traits studied.

Table 1. Mean squares from the analysis of variance for different traits among the sunflower inbred lines evaluated under different irrigation treatments.

		Mean of square					
SOV	**DF**	**Seed Yield**	**Head diameter**	**1000 seed weight**	**No. seed per head**	**Stem diameter**	**Plant height**
Block	2	1100.54^{ns}	34.92**	193.96^{ns}	250673.62^{ns}	8.7*	646.19^{ns}
Stress	2	2943.24*	84.95**	1357.53*	212545.53^{ns}	25.63**	1274.78*
Error 1	4	201.591	0.594	132.55	46701.11	0.91	154.08
Lines	8	529.56**	39.73**	1046.87**	200596.55**	19.38**	617.25**
Line×Stress	16	169.61^{ns}	6.57^{ns}	82.9^{ns}	41730.99^{ns}	2.7^{ns}	89.04^{ns}
Error 2	48	150.584	6.08	76.85	41407.8	3.14	106.4
CV% 1		45.07	6.15	25.85	30.38	7.45	13.53
CV% 2		38.95	19.68	19.68	28.60	13.84	11.24

Table 2. copparsion of different water stress treatment means in different traits studied

	Seed Yield	**Head diameter**	**1000 seed weight**	**Stem diameter**	**Plant height**
Control	43.13^{a}	14.61^{a}	52.02^{a}	13.53^{a}	99.59^{a}
mild stress	28.44^{b}	11.74^{b}	43.69^{b}	12.11^{b}	86.72^{b}
Severe stress	22.93^{b}	11.32^{b}	37.9^{c}	11.66^{b}	88.99^{b}

The mean values of all characters measured in different treatments are summarized in (Table 1).Mean values of different traits of sunflower lines under normal irrigation and water stress conditions exhibited that under water stress the average performance of the lines was decreased for all the characters under study. Normal irrigation produced the highest value for all the traits studied,and there was no differences between two limited irrigation treatmentsfor seed yield, head diameter, stem diameter and plant height (Table 2). Drought stress either at budding or flowering reduced plant height of sunflower and more reduction in plant height was measured when water deficiency occurred at bud initiation (Unger, 1983)

Seed yield per head data indicated that the maximum seed yield of 43.13 gr.plant-1 was obtained by applying normal irrigation, while two limited irrigation decrease the yield of lines significantly, and there was no difference between two limited irrigations. The maximum seed yield might be due to increased 1000 seed weight and head diameter (Table 2). Head diameter of sunflower was significantly decreased under drought and more decrease in head diameter occurred when crop faced drought at flowering than budding (Hussain *et al.*, 2000). This reduction was due to decrease in production of photosynthesis (Tezara *et al.*, 1999) and their less allocation to the floral organs (Setter *et al.*, 2001). It has been found that both quantity and distribution of water has a significant impact on achene and oil yield in sunflower (Rauf, 2008). Seed oil content was sensitive to even mild water stress but showed stability under increasing stress conditions (Khan *et al.*, 2003). Although drought stress affects every developmental stage of sunflower, maximum reduction in yield was experienced when drought occurred during the reproductive stage (Rauf, 2008). Intensity of yield reduction by drought stress depends on the growth stage of crop, the severity of the drought and tolerance of genotype (Lorens *et al.*, 1987). On the other hand, stress during the flowering stage causes abortion of ovaries, embryo, sterility of pollen and decreases in leaf area index. This reduces the number of achene per head, 100-achene weight and fertile Achene per head (Baldini and Vannozzi, 1999)

Table 3. copparsion of sunflower inbred lines means in different traits studied

genotype	Seed Yield	Head diameter	1000 seed weight	No. seed per head	Stem diameter	Plant height
R19	31.24^{bc}	11.47^{bc}	44.62^{cd}	681.19^{bc}	11.67^{c}	**94.38^{b}**
R26	19.14^{c}	13.23^{ab}	40.55^{de}	474.95^{bc}	11.06^{c}	**78.15^{d}**
R50	27.96^{bc}	11.59^{bc}	43.41^{cd}	630.69^{bc}	11.62^{c}	**89.89^{bc}**
R56	39.01^{ab}	13.24^{ab}	62.95^{a}	598.41^{bc}	14.5^{a}	**96.57^{b}**
B147	38.14^{ab}	15.26^{a}	57.68^{ab}	647.18^{bc}	14.13^{ab}	**93.92^{b}**
B221	29.84^{bc}	13.89^{ab}	36.58^{def}	810.5^{ab}	12.51^{bc}	**94.75^{b}**
B329	44.11^{a}	15.25^{a}	50.45^{bc}	807.15^{ab}	14.17^{ab}	**106.88^{a}**
B343	28.38^{bc}	8.97^{d}	31.05^{f}	987.36^{a}	10.65^{c}	**88.27^{bcd}**
B355	25.72^{bc}	10.48^{cd}	33.54^{ef}	765.62^{b}	11.57^{c}	**83.09^{cd}**

Table 4. Eigen values and vectors of different traits for sunflower inbred lines.

	Component	values Eigen	Cumulative Proportion (%)	Seed Yield	Head diameter	1000 seed weight	No. seed per head	Stem diameter	Plant height
Normal irrigation	1	4.153	69.215	0.769	0.848	0.904	0.972	0.575	0.866
	2	1.325	22.084	-0.523	0.494	-0.323	0.125	0.761	-0.328
Mild drought stress	1	3.29	54.83	0.754	0.53	0.937	0.825	-0.41	0.845
	2	1.76	29.3	-0.385	0.63	0.273	0.463	0.884	-0.377
Severe drought stress	1	3.65	60.85	0.755	0.835	0.929	0.646	-0.537	0.902
	2	1.32	22	-0.005	0.265	0.019	0.699	0.831	-0.266

The data on stem diameter and plant height indicated that water stress treatment had a significant effect on these traits. And both of them had a maximum value in the normal irrigation. The data on 1000 filled seed weight revealed that water stress significantly influenced this parameter. normal irrigations gave the maximum 1000 filled seed weight of 52.02 gr. Sever water stress produced minimum seed weight of 37.9 gr. Increased 1000 seed weight resulting from more frequent irrigation might be due to the availability of adequate soil moisture and assimilates from source to sink during seed formation and seed ripping stages(Table 2). Reduction in seed number was due to a combination of reduced head size and of the area having viable seeds (Fereres *et al.*, 1986).

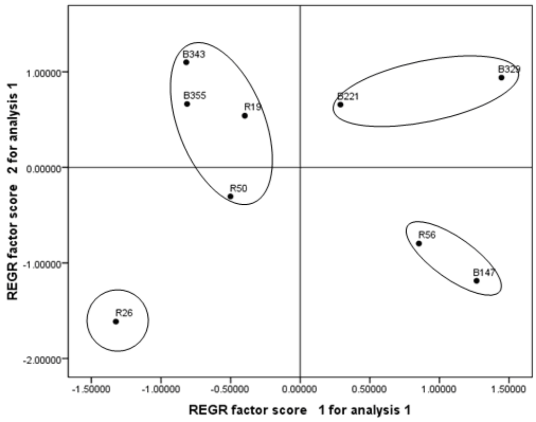

Fig. 1. Distribution of sunflower inbred lines based on two principal components in normal irrigation

similarly researches showed that Reduction in head diameter further decreases the number of rows per head and number of achene per head and results in correlation of yield components to severity of drought (Rauf and Sadaqat, 2007). The reduction in vegetative biomass results in lower plant surface area which reduces the radiation use efficiency and photosynthetic activities (Germ *et al.*, 2005). This finally lowers assimilation of photosynthesis during the reproductive phase which reduces head diameter.

Mean squares of different traits under drought and normal irrigation conditions (Table 1) revealed highly significant differences between sunflower inbred lines for all the traits studied.On the basis of individual behavior of inbred lines it was expressed that B329, R56 and B147 were less affected under water stress conditions as compared to other lines for seed yield per plant and head diameter. Inbred line B343 for number of seed per plant and inbred line R50 for 1000 seed weight were less affected too. Inbred lines B329 and R56 proved more droughttolerants for stem diameter and plant height (Table 3).

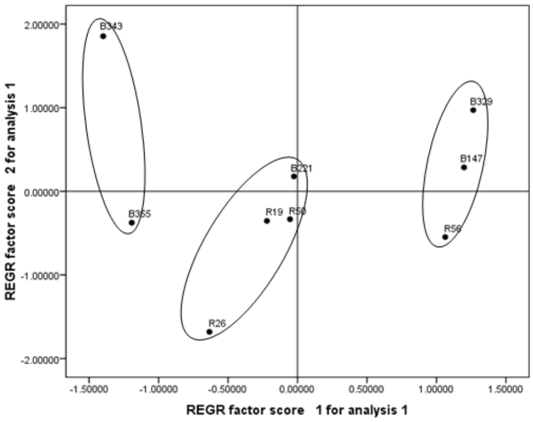

Fig. 2. Distribution of sunflower inbred lines based on two principal components in mild drought stress condition

Principle component analyses were shown for all three treatment studied. For all three the treatment first two components with eigenvalues of greater than one extracted. In normal irrigation condition two components explained 91.3% of variation. Frist PCA explained 69.22% of total data and had high positive correlation with all traits studied except number of seed per plant. And this component was able to separate all the lines with higher values for all the traits. The second PCA explained 22.08% of the total data variation and had just high positive correlation with number of seed per plant (table 4). In the normal irrigation condition biplot graph indicated the high differentiation between lines. Lines B329 and B221 were in the same group with high value in both PCs. Lines B147 and R56 had just high value in PC1.lines B343, B355, R19 and R50 located in a group with high in PC2. In other word, they had high number of seed per plant in this condition. Line R26 had low performance in all the traits studied (Fig. 1).

In mild drought stress condition the first two components explained 84.13% of total data variation. First PC explained 54.84% of total data variation and all the traits studied dad high positive correlation this PC except number of seed per plant. The second PC explained 29.3% of total data variation and had high positive correlation with number of seed per plant and plant height (table 4). In this condition lines B329 and R56 were in the same group that they have high value in PC1 in compare of other lines, while B329 was the best in PC1 and PC2. Line B147 was affected in this condition and mild drought stress decrease the performance of this line in both principle components. Considering to high performance of this line in normal irrigation condition, indicated that this line have low tolerance to drought stress. Lines R19, B147, B221, B355, R50 located in the same group. R26 was in a separate group that had the lowest value for PC2. Line B343 was in a separate group that had low value for PC1 and high value for PC2. This line had no considerable difference in normal irrigation and mild drought stress, which indicated low potential performance and high tolerance to drought (Fig. 2).

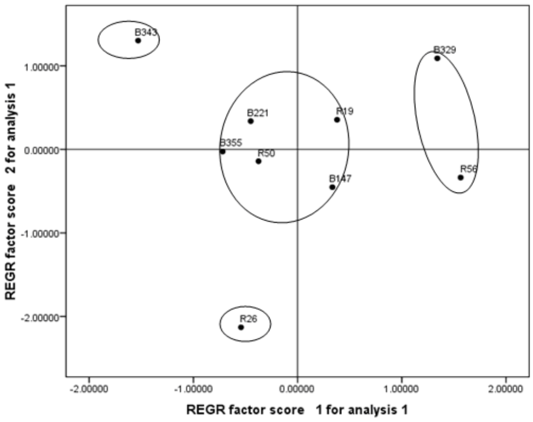

Fig. 3. Distribution of sunflower inbred lines based on two principal components in severe drought stress

In the severe drought stress all the traits studied had high positive effect on first PC except number of seed per plant and seed yield per plant (table 4). Number of seed per plant and seed yield per plant had high positive effect on the second. In other word the lines with high value in both principle components in drought condition are tolerant to this condition. Distribution graph of genotypes shows that lines B329, B147 and R56 were in the same group and they had high value in first component (Fig. 3). B329 was the best in both first and second component. Lines B343 and B355 had the least value in PC1. Lines B221, R19, R50 and R26 were in the same group in which line R26 had low performance in PC1.

References

Attene G, Porru A. 1990**.** Evaluation of sunflower cultivars in different environments and at different moisture availabilities. Sub-set B: cultivars of different precocity compared in different environments under dryland cultivation and with limited irrigation. Sardinia. Informatore Agrario **46**,49-50.

Baldini M, Vannozzi GP. 1999. Yield relationships under drought in sunflower genotypes obtained from a wild population and cultivated sunflowers in rain-out shelter in large pots and field experiments. Helia, **22**, 215–224.

Blum A. 1996. Crop responses to drought and the interpretation of adaptation. Plant Growth Regulation **20(2)**, 135-148 http://dx.doi.org/10 1007/BF00024010

Condon GA, Richards AR, Rebetzke JG, Farquhar DG. 2004. Breeding for high water-use efficiency. Oxford University Press, Oxford, ROYAUME-UNI, 14 p. http://dx.doi.org/10.1093/jxb/erh277

Fereres E, Gimenez C, Fernandez J. 1986. Genetic variability in sunflower cultivars under drought. I. Yield relationships. Australian Journal of Agricultural Research **37(6)**, 573-582 http://dx.doi.org/10.1071/AR9860573.

French R,Turner N. 1991. Water deficits change dry matter partitioning and seed yield in narrow-leafed lupins (*Lupinus angustifolius* L.). Australian Journal of Agricultural Research **42(3)**, 471 - 484 http://dx.doi.org/10.1071/AR9910471

Germ M, BERČIČ OU, AČKO DK. 2005. The response of sunflower to acute disturbance in water. Acta Agriculturae Slovenica **85**, 135-141.

Hussain MK, Rasul E, Ali SK. 2000. Growth analysis of sunflower (*Helianthus annuus* L.) under drought conditions. International Journal of Agriculture and Biology, **2(1-2)**, 136-140.

Khan MS, Swati MS, Khalil IH, Iqbal A. 2003. Heterotic studies for various characters in sunflower (*Helianthus annuus* L.). Asian Journal of Plant Sciences, **2(14)**, 1010-1014.

Lawlor D, Cornic G. 2002. Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants. Plant, Cell & Environment, **25(2)**, 275-294 http://dx.doi.org/10.1046/j.0016-8025.2001.00814.x

Lawson T, Oxborough K, Morison JIL, Baker NR. 2003. The responses of guard and mesophyll cell photosynthesis to CO2, O2, light, and water stress in a range of species are similar. Journal of experimental botany, **54(388)**, 1743-1752 http://dx.doi.org/10.1093/jxb/erg186

Lorens G, Bennett J, Loggale L. 1987. Differences in drought resistance between two corn hybrids. II. Component analysis and growth rates. Agronomy journal, **79(5)**, 808-813 http://dx.doi.org/10.2134/agronj1987.00021962007900050010x

Pasda G, Diepenbrock W. 1990. The physiological yield analysis of sunflower (*Helianthus annuus* L.). Part II. Climatic factors. Fett Wissenschaft Technologie **93(5)**, 155-168 http://dx.doi.org/10.1002/lipi.19910930501

Rauf, S. 2008. Breeding sunflower (*Helianthus annuus* L.) for drought tolerance. Commun. Biometry Crop Science **3**, 29-44.

Rauf S,Sadaqat HA. 2007. Sunflower (*Helianthus annuus* L.) germplasm evaluation for drought tolerance. Communications in Biometry and Crop Science **2(1)**, 8-16.

Reddy AR, Chaitanya KV, Vivekanandan M. 2004. Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. Journal of Plant Physiology **161(11)**, 1189-1202 http://dx.doi.org/10.1016/j.jplph.2004.01.013.

Setter TL, Flannigan BA,Melkonian J. 2001. Loss of kernel set due to water deficit and shade in maize. Crop Science, **41(5)**, 1530-1540 http://dx.doi.org/10.2135/cropsci2001.4151530x

Tezara W, Mitchell V, Driscoll S, Lawlor D. 1999. Water stress inhibits plant photosynthesis by decreasing coupling factor and ATP. Nature, **401(6756)**, 914-917 http://dx.doi.org/10.1038/44842

Voltas J,López-Córcoles H,Borrás G. 2005. Use of biplot analysis and factorial regression for the investigation of superior genotypes in multi-environment trials. European Journal of Agronomy **22(3)**, 309-324 http://dx.doi.org/10.1016/j.eja.2004.04.005.

Unger PW. 1983. Irrigation effect on sunflower growth, development, and water use. Field Crops Research **7**, 181-194 http://dx.doi.org/10.1016/0378-4290(83)90021-7