International Journal of Modern Agriculture
ISSN: 2305-7246
Volume 10 Issue 3, 2021

Tolerant Evaluation of Different Cultivars of Sunflower (Helianthus Annus L.) Against Drought Stress

Ashkan Rahimi Shirazi[1], Mehdi Madandoust[2]*

[1] Agronomy Student, Fasa Branch, Islamic Azad University, Fasa, Iran
[2]Agronomy Department, Fasa Branch, Islamic Azad University, Fasa, Iran
*Corresponding author: mehdimadandoust@yahoo.com

Abstract

This study showed the effects of drought on germination ability and growing of four sunflower genotypes: Alstar, Armaviresky, Haison25 and Uoroflour in laboratory and greenhouse. The experiment was conducted using factorial experiment based on a completely randomized design with four replications. In the laboratory, drought condition was induced by PEG 6000 at the same potentials of 0 (control), -0.2, -0.4, -0.6 and -0.8 MPa. In greenhouse drought condition was induced by using identify field capacity method with five levels 100 (field capacity), 85, 70, 55 and 40% of field capacity. Results revealed that germination percentage and rate, dry weight of hypocotyl and root, length and dry weight of plants and LAI decreased markedly in osmotic potential -0.6 and -0.8 MPa and at 55 and 40% of field capacity. A moderate water stress caused a marked increment in root growth. Also, among these varieties, Alstar and Haison25 were the most tolerant of drought stress.

Keywords; Sunflower, drought, seed vigor, vegetative growth indices.

Introduction

Sunflower (*Helianthus annuus* L.) is becoming an increasingly important source of edible vegetable oil throughout the world because of its high polyunsaturated fatty acid content and no cholesterol (Liu and Baird, 2003). Since Iran has an arid and semiarid conditions and there is a bound diversity of climates, in order to know how this crop respond and adapt to drought stress can help to improve sunflower yield and planted areas. Generally, soil water deficit effects crop productivity from germination until grain filling and thus final grain yield (Yancey *et al*., 1982). Seedling emergence is one stage of growth that is sensitive to water deficit. Mwale *et al.* (2003) reported that emergence of seedling of sunflower limited in drought condition of soil. Kaya *et al.* (2006) also indicated that severity of drought stress caused limitation of rate and percentage of germination, length and dry weight of root and hypocotyls in sunflower and under -1.2 Mpa water potential, germination of seeds stopped completely. Also reported that rate and percentage of germination and early growth stage of sorghum (*Sorghum halupense* L.) (Sharma *et al.*, 2004) and rice (*Oriza sativa* L.) (Gill *et al.*, 2002) are decreased when the moisture supply is limited. Plants subjected to limited moisture at sowing time decreased their size (Lilley *et al.*, 2006). Moreover, their structural and functional alter, especially their leaves. Leaf area, cell size and intercellular space usually decreased, that it is demonstrated in sunflower (Frensch and Hsiao, 2014). Cellier *et al.* (2011), showed that the tolerant line of sunflower maintenance cellular turgor under drought stress. Pankovic *et al.*, (1999) reported that Increasing drought stress resulted in decreasing photosynthesis, accumulation of dry matter, stomata conductance and leaf area index of sunflower. The purpose of this research was to evaluate the association between morphological characteristics and drought stress tolerance during the seedling and vegetative stages by monitoring seedling and plant growth in four sunflower cultivars subjected to controlled drought condition in the laboratorial and greenhouse experiments.

Material and method

Four sunflower cultivars including Alstar, Armaviresky, Haison25 and Uoroflour, were evaluated in laboratorial and greenhouse experiments under stress (drought) and non-stress (control) conditions. The experimental design was a factorial experiment based on a completely randomized design with four replications.

Laboratorial stage

Drought stress was induced by polyethylene glycol (PEG 6000) treatment. Five drought stresses with different osmotic potentials of 0 (control), -0.2, -0.4, -0.6 and -0.8 MPa were arranged as described by Michel and Kaufmann (1973) Distilled water served as a control.

$T + (8.39 \times 10^{-7}) C^2 T - (1.18 \times 10^{-2}) C = \Psi$

$- (1.18 \times 10^{-4}) C^2 + (2.67 \times 10^{-4}) C$

Eq. 1

Osmotic potential (bar)= Ψ

C= PEG concentration ($gr.l^{-1}$)

T= temperature of experiment environment (°c)

Four replicates of twenty seeds of each cultivar were placed between filter paper in 10 cm diameter Petri dishes and 10 ml of respective test solutions added. In order to prevent evaporation, the door of Petri dishes closed. The Petri dishes were maintained at 25±1ºC in the growth chamber for 7 days. Duration of irrigation of each Petri dish was 8 ml on the first day, 2 cc in second day and 2 cc in fifth day Germination percentage was recorded every 24 h for 7 days (the seed was considered germinated when its root length was greater than 1 mm). Mean germination time (MGT) was calculated to assess the rate of germination (Ellis and Roberts, 1985) as follows:

MGT = (f/x) / F   Eq. 2

MGT = Mean germination time (day)

f = number of newly germinated seeds on each day

x = the day of counting

F= whole seed number

Then, Dry matter accumulation was measured after drying samples at 70ºC for 48 h in an oven.

Greenhouse stage

This stage carried out in greenhouse with ability regulation heat (temperature was adjusted to vary between 23°C and 16°C day/night), and relative humidity was set at 50±5. Seeds were planted in greenhouse characteristics and, after the cotyledons were fully expanded, seedlings were transferred to suitable drainage pots (ten seedlings of each cultivar were planted in each pot). After 7 days, strongest seedlings were selected for size and vigor. Drought condition was induced by using identify field capacity method and according to its duration of irrigation definite.

Eighty PVC pot (10 cm diameter and 25 cm height) filled with a clay loam field soil. 5 pots containing dry field soil were randomly selected and weighted. Then pot irrigated within saturation point and permitted them until ground water exited. At this time the weight of pots equaled field capacity point (control). Then 20, 40, 60 and 80% of field capacity was measured and it maintained by calculation weight of whole pots at 08:00 A.M for 45 days. After 45 days, plants bring out of pots and stem length and leaf area index was measured for each cultivar and stress treatment. Dry matter accumulation was

measured after drying samples at 70°C for 48 h in an oven.
For all investigated parameters, analysis of variance was performed using the MSTAT-C software package. Significant differences between the mean values were compared with Duncan test ($P < 0.05$).

Results and Discussion

Rate and percentage of germination

No apparent differences in the rate and percentage of germination in control level in the present study (data not shown) revealed that there were no differences in varieties genetically at control level and significant reduction in these factors in levels over -0.4 MPa were resulted increasing water osmotic potential and drought stress. Also, the lowest germination rate and the percentage were related to -0.8 MPa and concerned uoroflour cultivar. Between cultivars Alstar and Haison25 had the highest germination rate and percentage. The relationship between drought treatments and percentage of germination is presented in Figure 1. The following regression equation for this relationship was significant ($P < 0.01$).

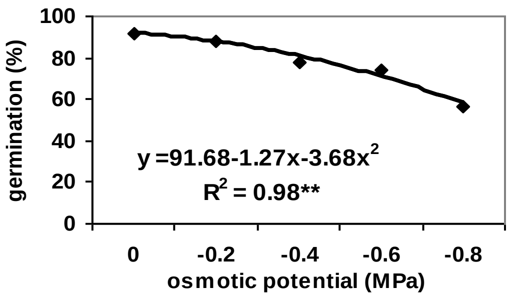

Fig. 1. Regression relationship of PEG concentration and sunflower germination percentage.

Dry weight of hypocotyls and root

Progressively increasing water stress, as imposed by the line source, affected hypocotyls and root dry matter accumulation significantly that it was sever in hypocotyls (Table 1). This is in agreement with earlier studies for sunflower (Angadi and Entz, 2002) which showed decreases in dry weight of hypocotyls and root as a result of simulated drought stress in seedling growth stage. Other researchers (Mwale *et al.*, 2003) reported that drought tolerant cultivars translocation of dry matter to the developing root to obtain more water from the sub layers of soil.

Table 1. Effect of drought on Germination percentage and rate and dry weight of Hypocotyl and root of sunflower.

Drought treatments (MPa)	Grmination percntage	Germination Rate	Hypocotyl dry weight (gr)	Root dry weight (gr)
0	95.63A	4.32 A	0.13A	0.12A
-0.2	87.50B	3.48B	0.10 B	0.11AB
-0.4	75.63C	3.16C	0.08C	0.12 B
-0.6	63.75D	2.44D	0.08D	0.07C
-0.8	51.88E	1.71E	0.05E	0.05D
Cultivars				
Alstar	77.50a	3.180a	0.08c	0.11b
Armaviresky	79.00a	3.075a	0.10b	0.12a
Hyson25	76.00a	2.725b	0.11a	0.10b

Means within a column followed by the same lower case together and same capital letter together were

Uoroflour	67.00b	3.100a	0.05d	0.04c

not significantly different (Duncan 5%).

Green house stage

plant height

The height of plant decreased recognizably with increasing water osmotic potential in this study and Alstar and Uroflour cultivars had the highest and lowest plant height, respectively (Table 2). Hanson (2010) revealed that decreasing in stem length under water deficit condition is related to decrease pressure turgor and decline in dry matter production

Table 2. Effect of drought on height and dry weight of Plant and leaf area of sunflower.

FC (%)	Plant height (cm)	Plant dry matter weight (gr)	Leaf area (cm^2)
100	43.44A	0.82A	294A
85	38.88B	0.56B	252B
70	33.94C	0.44C	160C
55	27.06D	0.27D	60D
40	26.06D	0.21E	45D
Cultivars			
Alstar	38.75a	0.46b	2.18a
Armaviresky	33.25b	0.53a	1.59b
Hyson25	31.80b	0.50ab	1.46c
Uoroflour	31.70b	0.34c	1.26c

Means within a column followed by the same lower case together and same capital letter together were not significantly different (Duncan 5%).

Plant dry matter accumulation

Significant differences were observed between treatments (drought levels and well-watered pots) for plant dry matter accumulation, indicating the effectiveness of the treatment to impose stress (Table 2). The reduction in dry matter accumulation of treated plants (40% FC) with respect to the well-irrigated (controls) was (0.21 g and 0.82 g, respectively). Seems that water stress reduces plant growth rate and thus biomass production. These results related with previous observation, so that stated that when plants experience water deficits, stomatal pores progressively close. Stomatal closure leads to decreases in photosynthetic CO_2 assimilation due to restricted diffusion of CO_2 into the leaf in sunflower (Batlang, 2006).The relationship between drought treatments and dry matter accumulation is presented in Figure 2. The following regression equation for this relationship was significant ($P < 0.01$).

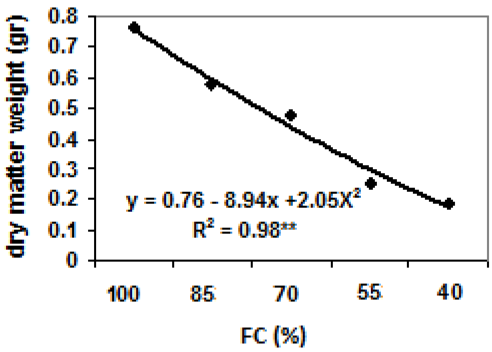

Fig. 2. Regression relationship of FC percentage and sunflower dry matter weight.

Leaf area index

Leaf area showed high sensitivity to water stress and decreased when water was limiting (40, 55, 70, 85% 0f field capacity) and resumed when water was more available (field capacity) (Table 2). Ludlow and Mucho (16) showed that relative water content (RWC) of the leaves decreased under drought stress. Also, Mwale *et al.* (2003) showed that the relative water content of sunflower decreased under drought stress condition even though the it`s rate was lower in tolerant cultivars. The relationship between drought treatments and leaf area index is presented in Figure 3. The following regression equation for this relationship was significant ($P < 0.01$).

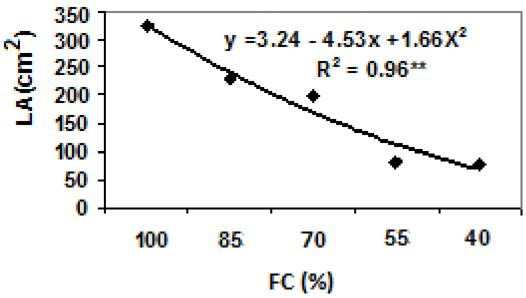

Fig. 3. Regression relationship of FC percentage and sunflower leaf area

Conclusion

In our study the driest matter accumulation and leaf area index was related to acquisition of drought tolerance characterized in Alstar and Haison25, thereby, early vigor (EV) and biomass at the first development stages, may be a positive trait to improve sunflower yield in water-limited environments (Pankovic *et al*., 1999) such as Iran. Consequently, there is need to improve the genetic tolerance of sunflower cultivars with this characteristic to adapted drought at the seedling and vegetative stages specially.

Referneces

1- Angadi, S. V., Entz, M. H. 2002. Water Relations of Standard Height and Dwarf Sunflower Cultivars. Crop Sci. J. 42:152-159.

2- Batlang, U. 2006. Studies with triazoles to alleviate drought stress in greenhouse-grown maize (*Zea mays*) seedlings. MSc. thesis submitted to the faculty of the Virginia Polytechnic Inst. and State Univ. 133 p.

3- Cellier, F., Conéjéro, G., Breitler, J.C. Casse, F. 2011. Molecular and physiological responses to water deficit in drought-tolerant and drought-sensitive lines of sunflower. Plant Physiol. J. 116:319–328.

4- Dart, A., Robert, M., Smillie, B., Norr, R. 2012. Sunflower lab performance and field emergence. Plant Physiol. J. 70: 1049-1054.

5- Ellis, R.H. and Roberts, E.H. 1985. Towards a rational basis for testing seed quality. In: Seed Production (ed: P.D. Hebblethwaite), p: 605- 635. Butterworths, London.

6- Frensch, J. and Hsiao, T.C. 2014. Transient responses of cell turgor and growth of maize roots as affected by changes in water potential. Plant Physiol. J. 104:247-254.

7- Germ, M., Bercic, O. U., Acko, D. K. 2005. The response of sunflower to acute disturbance in water Availability. Acta Agric. Slovenica. 1- 85.

8- Gill, P. K., Sharma, A. D., Singh, P., Bhullar, S.S. 2002. Osmotic stress-induced changes in germination, growth and soluble sugar content of (*Sorghum bicolor* L.) moench seeds. BULG. Plant Physiol. J. 28: 12–25.

9- Hanson, A.D., Peacock. W.J., Evans, L.T., Arntzen, C.T., Khush, G.S. 2010**.** Drought resistance in rice. Nature 345: 26-27.

10- Kaya, M.D., Okçu, G., Atak, M., Çıkılı, Y.,Ö. Kolsarıci. 2006. Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annus* L.). Eur. J. Agron. 24: 4 291-295.

11- Lilley, J. M., Ludlow, M. M., McCouch, S.R., O'Toole, J. C. 2006. Location of QTL for osmotic adjustment and dehydration tolerance in rice. Exp. Bot. J. 47**:** 1427-1436.

12- Liu, X., Baird, W.V. 2003. Differential Expression of Genes Regulated in Response to Drought or Salinity Stress in Sunflower. Crop Sci. J. 43:678-687.

13- Ludlow, M. M., Mucho, R.C. 2010. A critical evaluation of possibilities for modifying crops for higher production per unit rainfall. In: Bidinger, F. R. Janson, C. R. (Eds). Drought resistance priorities for the dryland tropics. ICRISTA, Patancherue, India: pp. 179-211.

14- Michel, B.E., Kaufmann, M.R. 1973. The osmotic potential of polyethylene glycol 6000. Plant Physiol. J. 51: 914-916.

15- Mwale, S.S., Hamusimbi, C., Mwansa, K. 2003. Germination, emergence and growth of sunflower (*Helianthus annus* L.) in response to osmotic seed priming. Seed Sci. and technol. J. 31: 199-206.

17- Pankovic, D., Sakac, Z., Kevresan, S., Plesnicar, M. 1999. Acclimation to long-term water deficit in the leaves of two sunflower hybrids: photosynthesis, electron transport and carbon metabolism**.** J. Exp. Bot. 50: 127-138.

18- Sharma, A.D., Thakur, M., Meenakshi, R., Singh, K. 2004. Effect of plant growth hormones and abiotic stresses on germination, growth and phosphatase activities in *Sorghum bicolor* L. Moench seeds. Af. J. Biotechnol. 3: 308-312.

19- Yancey, P. H., Clark, M. E., Hand, S. C., Bowlis, R.D., Somero, G. N.1982. Living with water stress: Evolution of osmolyte system. Sci. 217: 1214–1222.