



A Study about Some Physiological Indices of Sunflower Growth Under Drought Stress

Mohammad Hadi Hemmati, Ali Soleymani*

Department of Agronomy and Plant Breeding, Isfahan (khorasgan) Branch, Islamic Azad University, Isfahan, Iran.

ABSTRACT

In order to study the effect of drought stress on some growth indices of oil sunflower cultivars, a study was conducted in Isfahan. The experiment was conducted as split plots in a randomized complete blocks design with three replications in Isfahan (51° 48' E, 32° 40' N). Main plots were drought stress in four levels (80, 100, 120, and 140 mm evaporation from evaporation pan class A and cultivars were sub plots (Sirena, Record, Euroflore). Total dry weight, leaf area index, net assimilation rate and crop growth rate were measured. Results showed that total dry matter, leaf area index, net assimilation rate and crop growth rate were decreased by drought increasing from 80 to 140mm. The least evaporation (80mm) had the highest amount of mentioned traits. Among cultivars, Record had higher total dry weight because of having growth period and then higher LAI, stem dry weight, leaf dry weight and capitulum dry weight but it had lower NAR and CGR because of higher LAI and shading of upper leaves, then it is recommended to use Record cultivar.

Key words: sunflower, drought stress, total dry matter, net assimilation rate, crop growth rate, leaf area index

INTRODUCTION

Sunflower is one of the most important oil crops which plays an important economical and agronomical role in crop rotation because of high oil quality. This crop is very flexible in bad environments. Water deficiency lessen net assimilation rate, dry weight of leaves, stem, and root and causes total dry weight and slow growth rate (Turner and Sobrado 1987). Tezara et al. (1995) observed that drought stress decreased net assimilation rate and water potential of sunflower's leaf. Chimenti et al. (2002) confirmed also intensive reduction in dry weight of sunflower due to water limitation. Rodriguez et al. (2002) announced that different dry matter accumulations under various soil moistures are dependent of genotypes. Karam et al. (2007) mentioned also that dry matter accumulation is increasing until capitulum yellowing and after that will lose because of falling of leaves. They reported that dry matter accumulation was reduced by enforcing low irrigation in early and middle of flowering but was not affected significantly at first of grain production. Leaf area index is the most important growth index of

sunflower which shows the highest sensitivity to water deficiency. Then, the main sign of water stress in vegetative phase of sunflower is reduction of number and size of leaves (Shiranirad.2000). Water stress in 4 to 8 leaves stage leads to smaller leaves, less leaf area index and less absorption at maturity stage (Koucheki, 1996). Fereres et al. (1983) found that leaf area was decreased rapidly by drought stress and affected grain yield negatively. Goksoy et al. (2004) announced that restricted irrigation reduced leaf area due to yellowing and falling leaves. According to reports of Soriano et al. (2004) Sunflower can reach to its maximum leaf area under full irrigation in proportion to water deficiency. karimzadeasl et al. (2004) ascribed the effect of water deficiency to falling leaves and reduction of leaf area. SanJose (1989) believed that crop growth rate was reduced by low available water because of reduction in leaf area index. Andrade (1995) showed that growth rate of sunflower was increased until flowering and then was reduced due to rapid aging of leaf. Plant which has high leaf area index can control the amount of input energy via changing in Stomatal conductance and saving water with closing stomata among drought period, however this method is not useful because respiration is continued and plant has to save a big area of heated leaves which loose water slowly from cuticle without any photosynthesis. The better way is controlling the leaf area (Shelek et al.1988). In another study (Cox and Jolliff. 1986) water stress in vegetative phase caused shorter plants and lower dry matter of sunflower. Even small water stresses can reduce leaf growth rate and leaf number among vegetative phase and decreases leaf area index after that. Sobrado and Turner (1987) reported that water deficiency reduced net photosynthesis and leaf dry weight of sunflower but increased the ratio of root to shoot.

This study was conducted to examine the effect of drought stress on growth properties of their sunflower cultivars in Isfahan (Iran).

MATERIAL AND MTHODS

The study was conducted in 2011 as split plot in randomized blocks design with three replications. Main plots were irrigation in four levels (80, 100, 120, and 140mm evaporation from evaporation pan class A) and sub plots were three sunflower cultivars (Record, Euroflore, and Sirena). Soil preparation was done and seeds were sown at June 8th. Every plot had five lines with six meter length, 60cm inter row space and 14cm distance between plants to reach to twelve plants per square meter. Needed fertilizers were used according to soil analysis test. Weeding and thinning were done at 4 leaves stage. Irrigation was done according to 80mm evaporation until plant establishment and after that irrigation treatments were enforced. Sampling was done every 15 days and at the time of maturity considering marginal effects. In order to calculate trends of total dry matter, leaf area index, net assimilation rate, and crop growth rate the best regression equations of Soleymani et al. (2003) were used:

$$1 \quad LAI = e^{a_1 + b_1 t + c_1 t^2}$$

$$2 \quad W = e^{a_2 + b_2 t + c_2 t^2}$$

$$3 \quad NAR = (b_2 + 2c_2 t) e^{(a_2 - a_1) + (b_2 - b_1)t + (c_2 - c_1)t^2}$$

$$4 \quad \text{CGR} = \text{NAR} \times \text{LAI} = (b_2 + 2c_2t) e^{a_2 + b_2t + c_2t^2}$$

Which W is total dry matter (g/m^2), t is time (day number after emergence), and a_1 , b_1 , c_1 , a_2 , b_2 , and c_2 are regression coefficients. Obtained data were analyzed using MSTAT-C program. Mean comparison was done using Duncan's multiple ranges test at 5% probability level. Graphs were drawn using Excel program.

Preparation method of tarragon powder

To prepare the experimental rations, tarragon plant was purchased on October from vegetable market in Khoy. After cleaning and removing mud and weeds and also non usable parts of the plant, it was placed on the clean cloth, and dried under proper room temperature, shade. The dried samples were powdered at the mill powders, and were added to the experimental rations.

RESULTS AND DISCUSSION

Total dry matter

Study of total dry matter shows that there was no significant difference between irrigation treatments until 50 days after sowing but it was increased and reached to maximum at 72nd day. Afterward, dry matter was reduced until the end of the growing season because of falling leaves and reduction in amount of plant moisture which this reflex is probably because of shading upper leaves on below leaves. Results showed that by increase in stress, dry matter was reduced. It means that plants has terminated its growth period faster which has led to shorter life period and less weight of plant organs like stem, leaf, capitulum, and finally total dry weight (figure1). The highest accumulated dry matter was belonging to 80mm treatment whereas 140mm had the least. Rising trend of dry matter accumulation was continued until maturing in all irrigation treatments and after that total dry matter was reduced due to falling of plant organs like leaves. Intensive stress produced the least dry matter via shortening growth period and lessening stem and capitulum diameters, plant height, leaf area and increasing the number of unfilled grains. Meanwhile, reduction in plant photosynthesis (caused by these stresses) followed by smaller size of plant and lower photosynthetic area. The trend of total dry matter for various cultivars show that it was increased until 72 days after emergence without any significant differences between cultivars and after that Sirena and Euroflore were the same but Record produced higher dry matter at about 80th day via higher capitulum and stem weights. By the end season total dry matter was reduced because of falling leaves and moisture reduction which Sirena and Euroflore cultivars showed more reduction than Record (figure2). The effect of irrigation treatments on total dry matter (table1) was significant highly ($P < 0.01$) and 80mm treatment had the highest total dry matter ($1897 \text{ g}/\text{m}^2$.table2), whereas 140mm produced the least ($1033 \text{ g}/\text{m}^2$). Also, cultivars had very significant effect on total dry matter ($p < 0.04$) and Record produced the highest total dry matter ($1535 \text{ g}/\text{m}^2$) while Euroflore produced the least ($1458 \text{ g}/\text{m}^2$). This is because of genetic differences of cultivars.

Table1 - variance analysis results of studied traits

Sources variation	Degrees of freedom	Mean squares					Leaf area index
		Leaf dry weight	Stem dry weight	Capitulum dry weight	Total dry matter	Leaf area index	
Replication	2	422.88	63.96	178.95	43627.08	0.75	
Irrigation	3	35928.55**	36713.76**	44385.68**	1271085.88**	26.76**	
Error(a)	6	596.75	167.01	94.09	1948.38	0.34	
Cultivar	2	6352.39**	8594.04**	9877.44*	17893.75**	0.008	
Irrigation * cultivar	6	833.15**	572.36**	1620.04**	1809.49	0.003	
Error (b)	16	158.81	9.83	49.95	1367.01	0.003	

* and ** significant at 5% and 1% probability levels, respectively

Table2- means comparison of studied traits

Sources variation	Leaf weight (g/m ²)	Stem dry weight(g/m ²)	Capitulum dry weight(g/m ²)	Total dry matter (g/m ²)	Leaf index	area
Irrigation*						
80	221.2a	318.8a	352.3a	1897a	6.6a	
100	153.7b	252.6b	313.6b	1675b	5.5ab	
120	105.1c	195.7c	291.6c	1367c	4.5b	
140	76.9c	176.9c	188.0d	1033d	2.5c	
Cultivar						
Sirena	119.2b	211.1c	281.5b	1486b	4.7a	
Record	134.2b	232.7b	317.2a	1535a	4.7a	
Euroflore	164.4a	263.4a	260.4c	1458b	4.7a	

*(mm evaporation from evaporation pan class A)

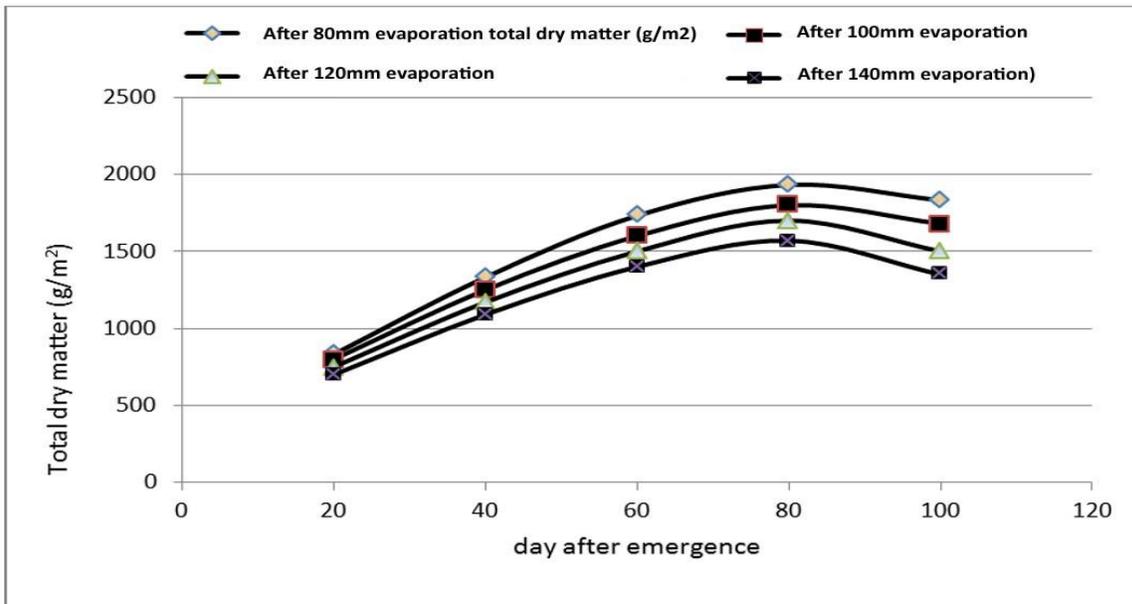


Figure1- Dry matter accumulation of various stress levels

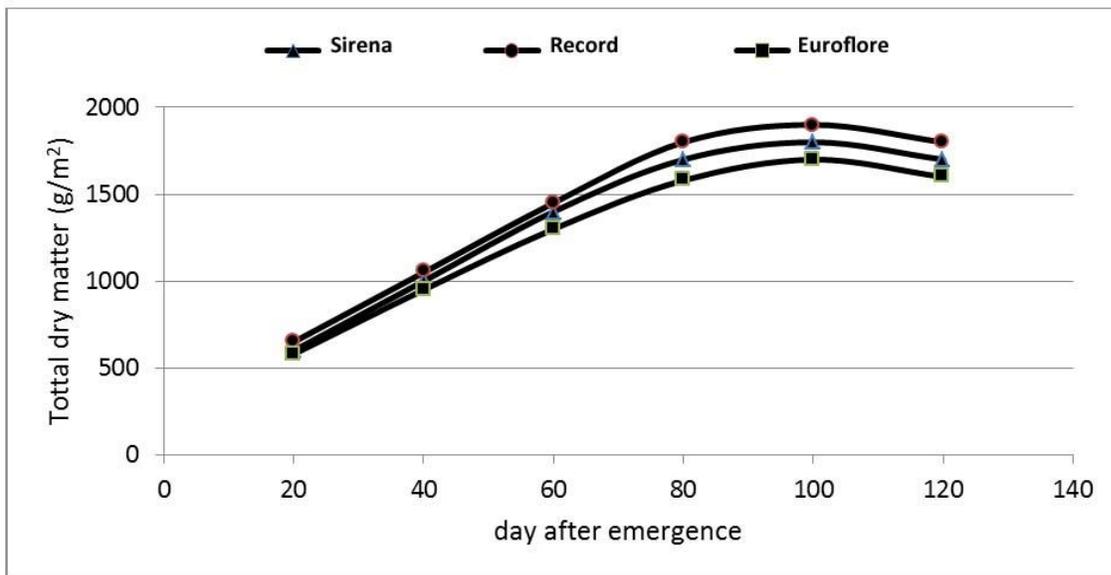


Figure2- Dry matter accumulation of various cultivars

Leaf area index

At first of growth period, leaf area index was at minimum because of non matured and not extended leaves. Therefore there was not considerable differences between treatments until fifty days after emergence but it was increased and reached to maximum at about 72nd day and after that was decreased until the end of growth period. Results showed that leaf area index was reduced by increasing drought stress so that 80mm treatment had the highest leaf area index among the growth season (figure3). Among cultivars the highest leaf area index was obtained at about same 72nd day and after that LAI was decreased due to lack of sufficient photosynthetic matters and falling leaves. Record cultivar had the highest leaf area index because of late maturity and high extension of leaf area (figure4). The effect of irrigation on leaf area index (table1) was very significant ($p < 0.01$) and 80mm treatment had the highest LAI (6.6) whereas 140mm produced the least (2.5) leaf area (table2). According to results, increase in drought stress reduced the LAI but 100mm treatment didn't have significant difference with 80mm treatment and also with 120 mm. Fereres et al. (1983) and Sadras et al. (1993) reported reduction of leaf area by increase in water stress in vegetative phase. Hejri (2008) showed also the same result in a study on sunflower. The effect of cultivar on leaf area index was not significant (table1) and cultivars showed the same leaf area. Valinezhad (2004) in a study on sunflower mentioned no significant difference between leaf area index of various cultivars. Interaction of irrigation and cultivar didn't effect this trait and there was not considerable trend also (table1).

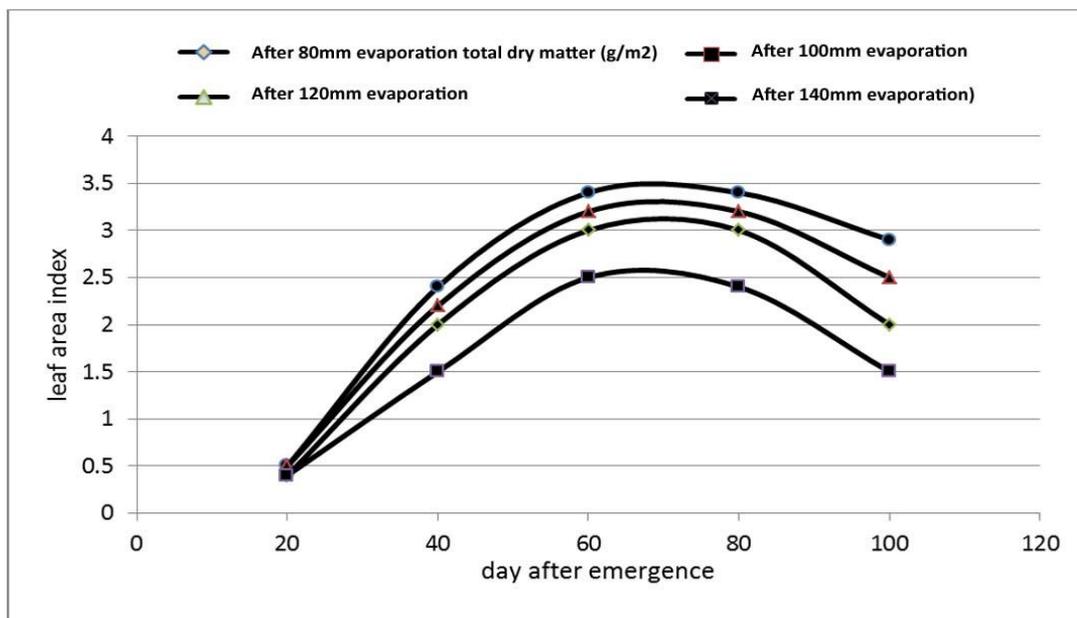


Figure3- leaf area index of various stress treatments

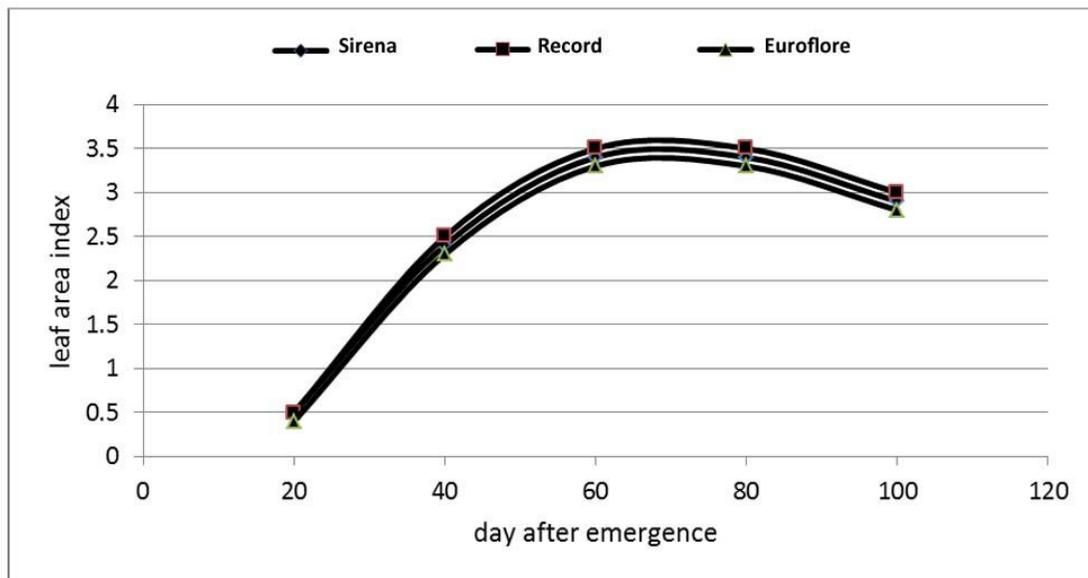


Figure4- leaf area index of various cultivars

Net assimilation rate (NAR)

Values concerning blood parameters and internal organs were compared by one-way analysis of variance (ANOVA) and *post hoc* Tukey-HSD test (SAS, 2003). Statistical significance was defined as $P < 0.05$. The study of net assimilation rate shows that all irrigation levels had similar trends and there was not significant difference between treatments. Net assimilation rate was at maximum at early growth stages because of minimum leaf area and lack of shading of upper leaves, but it was decreased and became negative after 80th day by increasing leaf area, shading and also aging of leaves (figure5). Hejri (2008) reported that the highest NAR was belonging to control treatment and after that low stress, high stress and intensive stress had next values, respectively. Among cultivars, net assimilation rate had falling trend and Record had the highest NAR for longer time because it was late mature and had higher leaf area at early growth stages and after that shading of leaves led to faster elimination of older leaves (figure6). Hejri (2008) also showed that net assimilation rate of all cultivars had falling trend and the highest amount of this trait was belonging to non-stress treatment. Also by increasing stress, NAR was decreased highly.

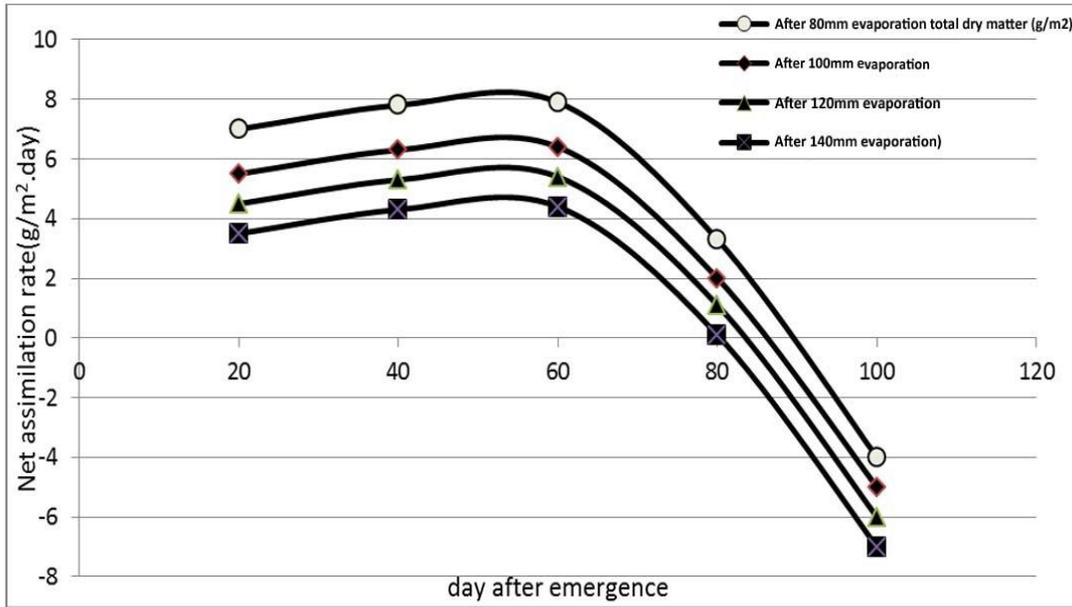


Figure5- net assimilation rate of various stress levels

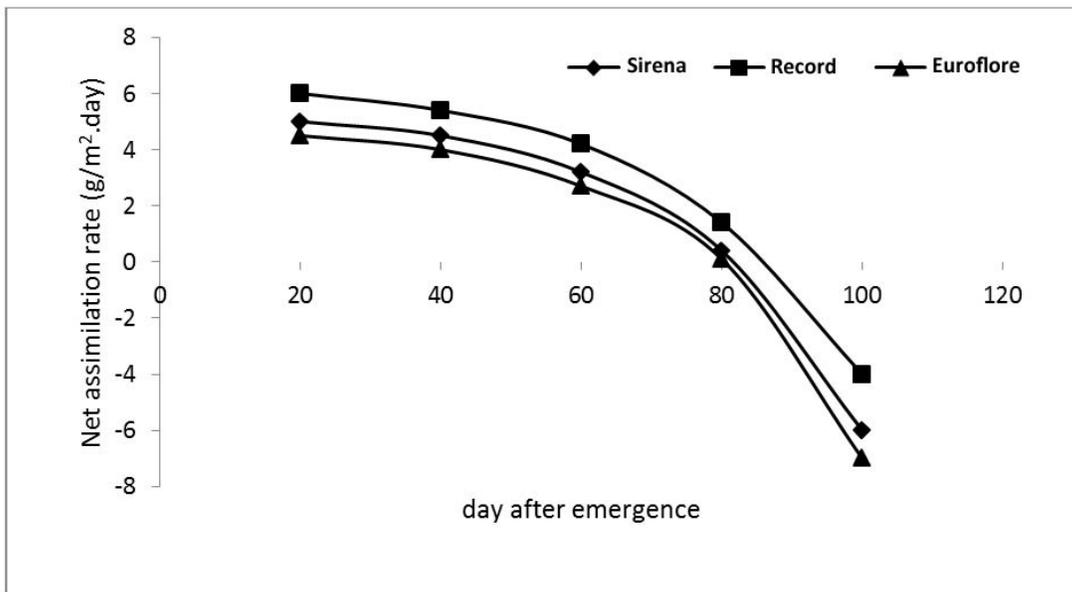


Figure6- net assimilation rate of various studied cultivars

Crop growth rate (CGR)

Changes of crop growth rate are completely similar to net assimilation rate and leaf area index. Then leaf area index plays main role in determining crop growth rate. Results showed that irrigation treatments didn't have considerable differences in early growth period but after a while and achieve to maximum leaf area, growth rate reached to its maximum. Afterward, because of leaves shading and falling of lower Leaves CGR was in minimum (figure7). Crop growth rate of

cultivars didn't have considerable difference until 50days after emergence but after that Record showed significant difference with other cultivars and then CGR began to fall and at about 80th day became negative. Record had the highest crop growth rate because of late maturity, higher leaf area index, leaf area duration and then more dry matter accumulation. Sirena and Euroflore were in next places (figure8).

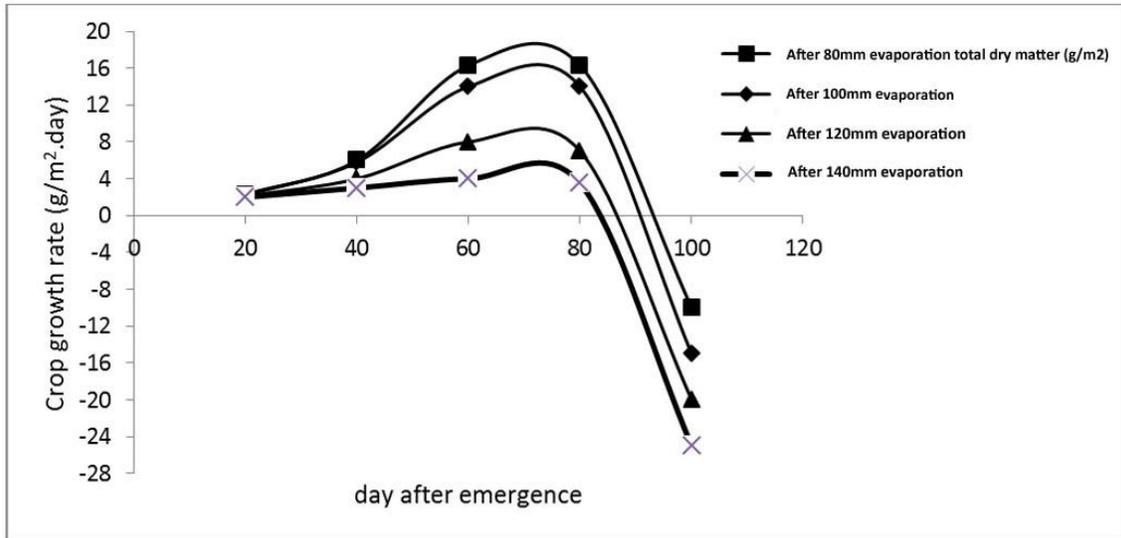


Figure 7-crop growth rate of various stress levels

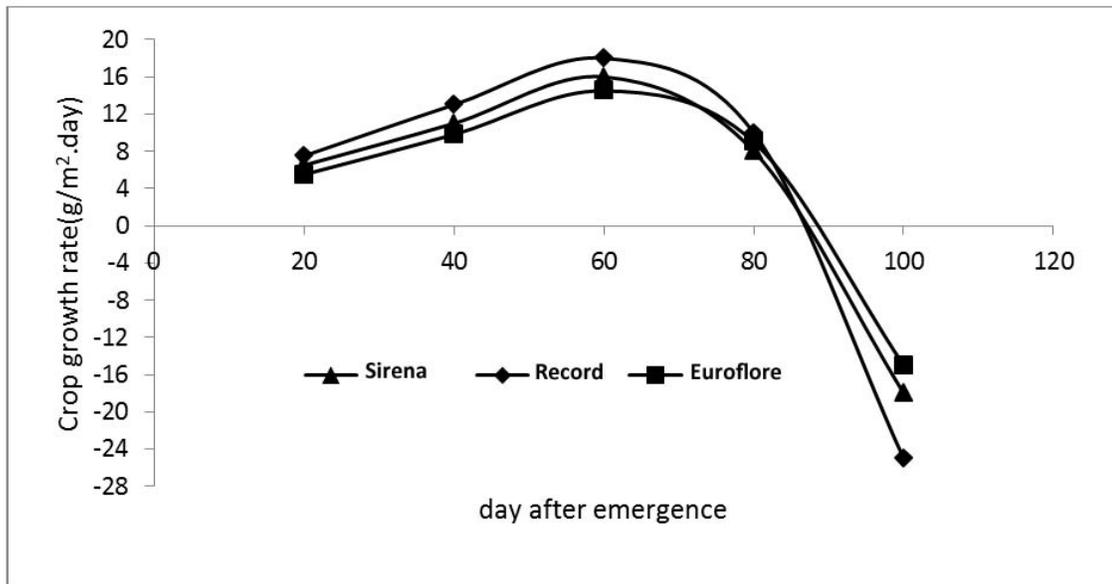


Figure 8-crop growth rate of various cultivars

REFERENCES

- Andrade FH. 1995. Analysis of growth and yield of maize, sunflower and soybean grown at balcarce, Argentina. *Field Crop Science*, 41: 1-12.
- Chimenti CA, Pearson J, Hall AJ. 2002. Osmotic adjustment and yield maintenance under drought in sunflower. *Field Crop Research*, 75: 235-246.
- Cox WJ, Jolliff GP. 1986. Growth and yield of sunflower and soybean under soil water deficits. *Agronomy Journal*, 18: 226-230.
- De Rodriguez J, Philips DBS, Rodriguez- Garcia R, Angulo-sanchez JL. 2002. Grain yield and fatty acid composition of sunflower seed for cultivars developed under dry land condition. In: J Janick, A wipkey (Eds). *Trends in new crops and new uses*. 2 nd edn, Ashs Press, Ajexandria VA, pp: 139-142.
- Fereres EC, Gimenez J, Berengan J, Fernandez JM , Dominguez J.1983. Genetic variability of sunflower cultivars in response to drought, *Helia*. 6:17-21.
- Goksoy AT, Demir AO, Turan ZM, Dagustu N. 2004. Responses of sunflower to full and limited irrigation at different growth stages. *Field Crops Research*, 87:167-178.
- Hejri A. 2008. The effect of drought stress on growth indices, agronomical traits, yield and yield components of sunflower cultivars. MSc thesis. Agriculture faculty. Isfahan branch of Islamic Azad University.
- Karam F, Lahoud R, Masaad R, Kabalan R, Breidi J, Chalita C, Roupheal Y. 2007. Evapotranspiration, seed yield and water use efficiency of drip irrigated sunflower under full and deficit irrigation conditions. *Agricultural Water Management*, 90: 213-223.
- Karimzadeh-Asl KH, Mazaheri D, Peyghambari SA. 2004. Effect of four irrigation intervals on seed yield and physiological indeces of three sunflower cultivars. *Biaban*, 9(2): 255-266. (in farsi).
- Kouchaki A. 1996. *Agriculture in arid places*. Jahade Daneshgahi Press.202 pages
- Sadras VO, Villalobos FJ, Fereres E. 1993. Leaf expansion in field grown sunflower in response to soil and leaf water status. *Agronomy Journal*, 85:590-611.
- Sanjose JJ, Cabrera M. 1989. Biproduction and leaf area development sunflower II: Quantitative relationship in Savanna dry season. *Field Crop Abstract*, 42: 803-809.
- Shelek VB, Shined VS, Dahiphale VV. 1988. Effect of levels of phosphorus and potassium on growth and yield of rabi sunflower as influenced by irrigation and moisture stress. *Helia*, 37: 39-50.
- Shiranirad A.H. 2000. *Crop physiology*. Dibagaran Tehran Press.358 pages.

Soleymani A, Khajepour MR, Nourmohammadi GH, Sadeghian SY. 2003. Evaluation of some physiological parameters affecting growth of sugar beet under the influence of sowing date and plant arrangement. *Scientific and Research Journal*, 1: 105-123.

Soriano MA, Orgaz F, Villalobos FJ, Federes E. 2004. Efficiency of water use of early plantings of sunflower. *European Journal of Agronomy*, 21:465-476.

Tezara WD, Lowlar W, Mathis P. 1995. Effect of water stress on the biochemistry and physiology of photosynthesis in sunflower. *Photosynthesis from light to biosphere.- proceeding of the Xth International photosynthesis Congress. Montpellier, France, August 20-25*, pp: 625-628.

Turner NC, Sobrado MA. 1987. Photosynthesis dry matter accumulation and distribution in the wild sunflower and cultivated sunflower as influenced by water deficits. *Journal of Illinois plant Cell Environ. Field Crop*, 44: 435-436.

Valinezhad H. 2004. The effect of drought stress on some agronomical traits of sunflower cultivars. MSc thesis. Agriculture faculty. Isfahan branch of Islamic Azad University.