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The effect of water deficit on characteristics phisyological-chemical of sunflower (*Helianthus Annuus* L.) varieties

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Abstract

For evaluation water deficit stress and potassium rates effects on some morpho-physiological attributes of sunflower, an experiment was conducted in a RCBD based split plot factorial design in three replications in Islamic Azad University, Tabriz Branch research field in 2008. Four sunflower cultivars as Airfloure, Alestar, Armawirski and Ismailli, along with three rates of potassium application as control, 75 and 150 kg/ha were arranged in subplots and three rates of water application after 70, 140 and 210 mm evaporation from Class A pan were arranged in main plots. The results showed that the application of water deficit stress decreased significantly plant height, seed number per head, seed hollowness percent, leaf water potential, leaf area index, leaf relative water content, stomatal resistance and harvest index. In water application after 70 mm evaporation from Class A pan Airfloure and Alestar cultivars had the highest seed number per head and the least hollowness percent, while maximum harvest index was obtained in Airfloure cultivar in consumption of 75 kg/ha potassium sulphate and water application after 210 mm evaporation from Class A pan. Potassium affected leaf water potential and resulted to greater water content as 14.09% and supplied essential hydrostatic pressure to increasing head fresh weight consequently. Increasing irrigation level decreased leaf water potential as 31.71% and increased stomata resistance as 45.61%, consequently leading to 49.17% decrease in head fresh weight. Potassium application enhancement was paralleled with 26.69% increase in grain yield. Also stomatal resistance increased in all cultivars with increasing water application intervals.

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Introduction

Low irrigation is one of the methods for agricultural productions when available water is deficit (Lafitte, 2002). (Khalilvand and Yarnia, 2007) reported that in sunflower Azargol hybrid maximum chlorophyll content was 52.82 and its least content was 33.24 in control group and 25% of the available moisture respectively. Also, they proposed that drought stress condition increased stomatal resistance as a result of relative closing of stomata, consequently this condition increases the total resistance of the given plant against its H_2O movement in comparison Co_2. (Nistani, 2003) reported that the relative water content of lentil's genotypes which exposed to water deficit stress was less than genotypes which were not exposed to such condition. During drought period potassium was prominent ion in compare with other ions in tropical grasses, soybean, and corn and also it had an osmotic regulator role (AL-Moshileh and Errebi, 2004). (Chackmac, 2005) reported that in legumes and graminose sufficient potassium consumption in dry condition causes seed yield reduction through effect on photosynthesis process. (Anderson and Behboudian, 2004) reported that potassium maintains the balance of electoral charge in chloroplast in order to form ATP requirements. Therefore potassium causes the transmission of radiated energy into primary energy in the forms of ATP and NADPH. (Lahlou *et al.*, 2003) stated that Kardinal species at the water stress condition had relatively low development of stem and leaf growth and more concentration of dry materials in its glands in compare with Alfa species. (Khosravifar *et al.*, 2008) reported that in Agria cultivar of potato the maximum content of chlorophyll was 72.396 and its minimum content was 37.63 during the irrigation after 175 mm and 35 mm evaporation from class A pan respectively. Also they stated that in the application of 75 kg/ha potassium and irrigation after 175 mm evaporation the maximum and minimum number of stomata in abbaxial and addaxial leaf sides was 68.62 was 23.31 respectively, however they were 57.70 and 10.13 in irrigation after 150 mm evaporation. At drought stress condition leaf water potential (LWP) and relative water content are reduced and photosynthesis, leaf development, accumulation, and stomata sizes are influenced generally (Afkari Bajehbaj 2009, Lafitt 2002, Zlatev and Stotanov 2005). (Lahlou *et al,*. 2003) showed that leaf water potential of Remaka, Desiree, Nicola and Monalisa cultivars of potato decreased with drought stress. (Egilla *et al,*. 2001) showed that adequate potassium supply improved leaf water content (LWC) and leaf relations in Hibiscus (Hibiscus vosa-sinensis), this sustained net photosynthesis, transpiration and stomatal conductance in drought and non-drought stress. (Moorby *et al,*. 1975) reported that one of the first effects of drought period on potato is the reduction of photosynthesis rate, mainly caused by an increase in stomatal resistance. (Tourneux *et al,*. 2003) reported that Solanum juzepezukii cv. Lucky showed a capacity of drought adaptation due to high stomatal resistance, and also cv. Alfa showed the least water deficiency and stomatal resistance during drought period (Mojayad and planchon 1998). Sunflower crop is a heavy remover of soil potassium (Ewing, 1997). And its response to potassium varied with variety, source and method of potassium fertilizer application (Lahlou *et al,*. 2003). At harvest, the heads have accumulated about 78% of plant total K (Khosravifar *et al,*. 2008). Under drought condition grain yield was less in inadequate potassium supply in compare with adequate potassium (Khosravifar *et al.* 2008). Plants suffering from environmental stresses like drought have a large internal requirement for K (Chackmac, 2005). The purpose of this study was to evaluate of physiological traits in condition water deficit and the role potassium rates application in decrease was the effects water deficit of sunflower cultivars in Tabriz, Iran.

Materials and methods

The experiment was conducted in a split plot factorial based on randomized complete block design with three replication in IAU Tabriz Branch research field in 2008.

Soil Tetural

Soil textural class of experimental field was sandy loam. Other soil characteristics were as follows: pH 8.2, available potassium 186 ppm, available phosphorus 5-6 ppm, total nitrogen 0.60% and organic carbon 1.05%.

Treatments

The treatments included four types of species: Airflour(V1), Alestar(V2), Armawirski(V3) and Ismailli(V4), Three water application levels after 70(S0),140(S1) and 210(S2) mm evaporation from class A pan and three potassium sulphate application rates as 0(K0), 75(K|) and 150(K2) kg/ha were arranged in main and sub plots, respectively. Potassium was supplied to soil before planting. Plot size was 4.5 m and x 6 m and consisted of 7 planting rows, distance 60cm.

Parameters

Leaf area and chlorophyll content were measured through leaf area meter (ADM) and chlorophyll meter (CM-200), respectively. Abaxial and adaxial stomata numbers were counted in view zone of microscope with 40 x magnification in object glass. Leaf relative water content (RWC) was measured from the third leaf situated on the top of the canopy in the flowering time through following equation (Taiz and Zeiger, 2002) : RWC = [(Wf- Wd)/ (Ws-Wd)] x l00. A pressure chamber (SKPM 1400) was used for leaf water potential measurement Stomatal resistance was measured on the base of sec/cm through a poremeter (AP4). Also to apply stress levels carefully soil moisture was measured for times by TDR. Leaf area, chlorophyll content, stomata number on both sides of leaf, water potential and stomatal resistance were also recorded during flowering period. Statistical analysis of collected data was done using SAS and MSTATC softwares with mean comparison by Least Significant Difference Test (LSD) in the 5% and 1 % probability levels.

Results and discussion

Except of adaxial stomata number and Grain number per head, irrigation level was significant in all evaluated attributes. Potassium application had significant effect on number of tiny and, grain number per head, head fresh weight and grain yield. Interaction between irrigation level and potassium fertilization was highly significant in leaf area, abaxial and adaxial stomata number, leaf relative water content, water potential content, stomatal resistance and grain number per head (Table 1).

Table 1. Analysis of variance of studied attributes.

Source of Variation	df	Mean of squares							
		Stomatl resistance	Abaxial stomata number	Adaxial stomata number	Leaf relative water contentt	Leaf water Potentil	Grain length (mm)	Grain number per head	Grain yield (kg/ha)
Replication	2	41371.1	7.19	187.93	141.63	0.97	231.81	11024.49	6759.37
Cultivar	3	0.085	5.422*	98.54*	0.091	8.768*	0.091**	7124567	18121.9
Error (a)	6	0.543	74.432	0.068	43.19**	0.698	0.005	515283.6	75432.07
Water deficit	2	11.321*	27.318	19.432	0.189**	10.739**	1.845**	62169.72**	563425.4**
W.D. cul.	6	0.645	5.217	31.991	41.69*	0.732	0.002	3321481.3*	98865.8**
Potassium	2	0.089	52.56	27.657	39.91*	0.061	0.002	5123493**	14121.83
Cultivar· P	6	0.034	22.98	31.545	44.33*	0.234	0.005	3603039**	15885.34
W.D. P	4	0.731	21.893	15.474	46.17	0.119	0.003	812454.90	68832.78*
cultivar·W.D.P	12	0.675	28.21	22.659	21.35	0.231	0.004	487532.85	48443.45
Error (b)	64	0.392	38.942	13.309	8.77	0.439	0.005	536631	23352.65
% CV		26.21	21.38	10.29	8.17	11.06	8.67	15.82	20.54

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

Adaxial Stomata Number

The least number of stomata on adaxial side of leaf was 22.5 in S0K0 and its greatest number was 26.7 in S0K2 (Table 2). This shows that the number of stomata on adaxial side of leaf increased with enhancement of potassium application(Fig. 5). It is possible that under water stress the occurrence of this phenomenon in plant is a useful strategy to increase atmospheric CO, absorption or carbon exchange rate (CER), because potato is a C3 plant and its Co2 saturated point is higher than in C4 plants (Premachandra *et al*,. 1991). In fact, in potato plant the number of stomata in a zone of leaf increased and enabled them to escape from stomatal hydropassive closure (Hopkins and Huner, 2004). The least abaxial stomata number was 23.8 in S0K2 and its maximum rate was 28.9 in S2K0. In all potassium application levels, abaxial stomata number increased from S0 to S1 of irrigation level, however, decrease was obvious in S2 irrigation level (Table 2). It is possible that decreasing abaxial stomata number toward S1 is not essential for sunflower, but when this crop was exposed to severe drought stress in S2, the crop responses to number of stomata on abaxial side of leaf and reduces their number on this side (Fig. 6).

Table 2. Mean comparison of interaction between irrigation levels and potassium application levels.

Irrigation level* Potassium application level	Stomatal resistance	Abaxial stomata number	Adaxial stomata number	Leaf relative water contentt	Leaf water Potential	Grain yield (kg/ha)	Number of grain per head	Grain length (mm)
S_0K_0	1.38	23.8	22.5	60.3	-13.7	4535	842.4	0.091
S_1K_0	1.93	24.9	23.2	51.3	-19.8	4092	830.48	0.005
S_2K_0	3.33	23.9	22.9	40.3	-23.14	3762	627.02	1.845
S_0K_1	2.18	24.8	23.9	63.7	-12.1	4671	917.85	0.002
S_1K_1	2.76	25.7	24.3	54.3	-13.9	4008	879.39	0.002
S_2K_1	4.66	24.6	23.8	41.3	-18.8	3212	683.06	0.005
S_0K_2	2.45	28.9	26.7	65.3	-11.3	5847	985.92	0.003
S_1K_2	3.10	27.3	24.8	48.4	-14.8	4121	849.41	0.004
S_2K_2	4.83	26.7	24.6	43.9	-16.2	2984	624.61	0.005
LSD 1%	2.497	7.286	8.33	13.523	2.564	837.8	161.3	0.131

Leaf Relative Water Content

In all potassium application levels, leaf relative water content decreased with increasing irrigation (Table 2). The comparison of the averages obtained from different amounts of water deficit stress levels on the relative water content showed significant differences (Fig. 2). In other words, among the irrigation periods there was significant difference just among irrigation after 70 and 210 mm. The most and least amounts of RWC was 83.4% and 68.5% in 140 and 210 mm evaporation respectively. On the base of above results there was not significant difference in RWC amounts with water deficit increase to irrigation after 140 mm evaporation. The higher leaves moisture, fresh weight and dry weight in 70 mm evaporation in compare with 210 mm evaporation were the reason of this object. Also accompany with pressure decrease in leaf cells water potential of leaf cells probably decreases to a relative amount, as well as with continues decrease in relative water amounts, the leaf water in tissues are hold with tissue materials and components. Similarly leaf water potential is decreased quickly which resulted in seed number decrease and reduces uniform seedling emergence ultimately. This result agreed with those obtained by (Tartar 2008, Khalilvand and Yarnia 2007, and Neistani, 2003). The consumption of potassium leads to a significant difference in the relative water content. There was not significant difference among non consumption of potassium and application of 75kg/ha of this fertilizer in RWC, but consumption of 150kg/ha potassium in compare with non consumption had a significant difference. (Khosravifar *et al*,. 2008) reported similar results in Agria cultivar of potato. Leaf relative water content was least in S2, with highest water stress, and was reduced with increasing potassium application. It can be suggested that under drought stress, the positive effect of potassium as an effective osmolyte in leaf water potential regulation is the cause of this subject. (Egilla *et al*,. 2001) reported similar results in hibiscus. Investigations showed that water movement into leaf depends on existence of water potential gradient between xylem and leaf, so that reduction in water potential of xylem decreases water potential gradient between xylem and leaf. Potassium causes osmotic regulation in leaf cells and reduction of leaf water potential consequently creating essential gradient to water movement from xylem toward leaf and improvement of leaf water content (Pier and Berkowitz 1987). Irrigation after 70 mm evaporation had significant differences with irrigation after 210 and 140 mm evaporation.

Leaf Water Potential

The comparison of averages obtained from the effects of different amounts of potassium on leaf water potential showed a significant difference. Therefore maximum and minimum amounts of leaf water potential in 150 kg/ha potassium consumption was -14.8 bar and -23.14 bar in irrigation after 70 and 140 mm evaporation respectively (Table 2). Among the cultivars Armawirski with -13.68 bar appropriated the maximum leaf water potential. In the lack of perspiration osmotic adjustment potential will be higher in genotypes and diminish of leaf water potential will be lower consequently. These results were agreement with those obtained by (Mojayad and planchon 1998, Khosravifar *et al*. 2008, Goksoy *et al*. 2004, Zlatev and Stotanov 2005). In compare with S0K0, the least leaf water potential decreased 35.58% and highest one increased51.02% . With increasing potassium application crop attempted to negative leaf water potential through osmotic regulation, by this way plant increases the difference between plant and soil water potential. (Lahlou *et al*,. 2003, khosravifar *et al*,. 2008) reported similar results. Decreasing leaf water potential decreased tuber yield. K-fed plants maintained high leaf water potential as compared with untreated maize (Premachandra *et al*,. 1991) and wheat (Pier and Berkowitz, 1987) plants. Potassium deficit can have a more injurious effect in drought areas (Mansfield and Atkinson, 1990).

Stomatal resistance

Maximum and minimum stomatal resistance was 3.195 Sec/cm and 1.447 S/cm in irrigation after 210 and 70 mm evaporation respectively. Stomatal resistance increase with ABA production enhancement as a result of turgor pressure decrease in water stress condition is the reason of this object. As well as stomatal resistance increased with gradual decreases in stomata size. If one leaf expose to water deficit condition the moisture of subsidiary cells will decrease, consequently stomata diameters, leaf area and relative water content decreased but stomatal resistance increased (Fig. 4). These subjects resulted in decreasing the same plants seed yield. The above results are agreement with those obtained by (Lahlou *et al*,. 2003, Mojayad and planchon 1998, Khalilvand and yarnia, 2007). The least stomatal resistance was 2.760 sec/cm in S0K2 and highest one 11.37 sec/cm in S1K2 In compare with S0K0 the least stomatal resistance was 41.18% and highest one 39.17%, respectively. Stomatal resistance had an increasing trend with increasing potassium application (Table 2). Existence of both least and highest resistance in K2 level of potassium application suggests an improvement in stomatal function and indicates an improvement in stomatal control of gas exchange with enhancement of potassium content. This can be effective on photosynthesis and yield through effects on carbon exchange rate (CER) and in other hand causes increase in plant water efficiency through prevention of water loss. This concept is similar with results of (Moorby *et al*,. 1975, Tourneux *et al*,. 2003).

Grain length

Grain length decreased with enhancement of irrigation level, so that the least and highest measure of this dimension was reached in S0 and S2, respectively (Fig. 3). In compare with S0 grain length in S0, S1 and S2 decreased 11.04, 19.31 and 33.65%), respectively. Decreasing cell turgidity, carbon assimilation, hydrostatic pressure, transportation efficiency, photosynthesis rate and substance accumulation in tubers under water deficit condition are some reasons of decreasing tuber dimension (Taiz and Zeiger, 2002).

Grain Number Per Head

Number of seed per head increased from S0 to S1, but after S1 number of seed per head decreased. In compare with S0 the number of seed per head in S0 and S1 increased 37.29% and 12.38%, respectively. In other hand the number of seed per heads in S1 and S2 decreased 19.18% and 31.78%, respectively. Application of potassium fertilizer in compare with non-supplying of potassium had positive effect on the number of seed per heads. In compare with K0 level, number of seed per heads in K0, K1 and K2 levels of potassium application increased 15.11, 29.10 and 17.26%, respectively. Seed size always increases with potassium application, and potassium supply causes increasing of large-size seeds (Perrenoud, 1993). Increasing potassium supply causes enhancement of seed size and this is useful in occurrence of drought stress or any kind of stresses (Imas and Bansal, 1999). Number of seed per head diminished with increasing irrigation level (Fig. 1). Similar result was reported by (Lahlou *et al*,. 2003, khosravifar *et al*,. 2008, khalilvad *et al*,. 2007). It is possible that increasing irrigation level and soil water potential through increasing matric potential in one hand and stomata closure in other hand, result to decreasing transpiration rate as an essential force to water movement in plant and exert a negative effect on fresh weight. In compare with S0 head fresh weight in S0, S1and S2 decreased 12.19, 45.82 and 49.17%, respectively. Head fresh weight increased with enhancement of potassium application which exerts a positive effect on head fresh weight completely. This can be as a result of improving stomatal function and stomatal distribution on leaf sides, in other hand potassium through decreasing plant water potential results to greater water conduction into plant and consequently through improving leaf relative water content and providing essential hydrostatic pressure results to greater tuber fresh weight , so that least and highest head fresh weight was in K() and K2 , respectively. Grain yield decreased with increasing irrigation level. This is similar with (Lahlou *et al*. 2003, khosravifar *et al*,. 2008, khalilvad *et al*,. 2007) results.

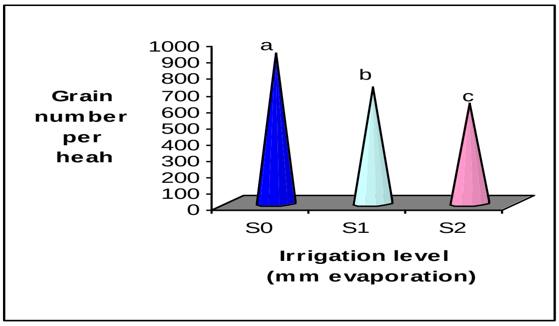

Fig. 1. Effect of irrigation level on grain number per head.

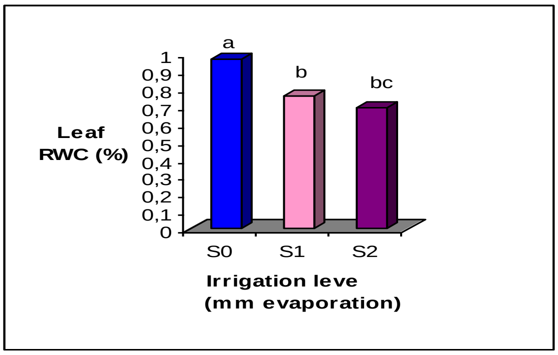

Fig. 2. Effect of irrigation level on leaf (RWC).

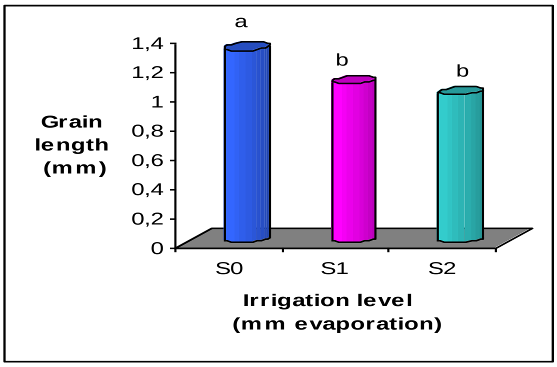

Fig. 3. Effect of irrigation level on grain length.

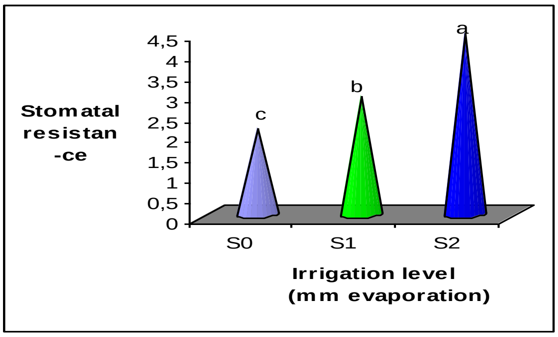

Fig. 4. Effect of irrigation level on stomatal resista.

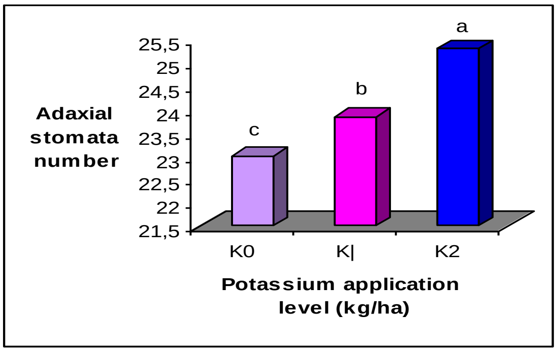

Fig. 5. Effect of potassium application on adaxial stomata number.

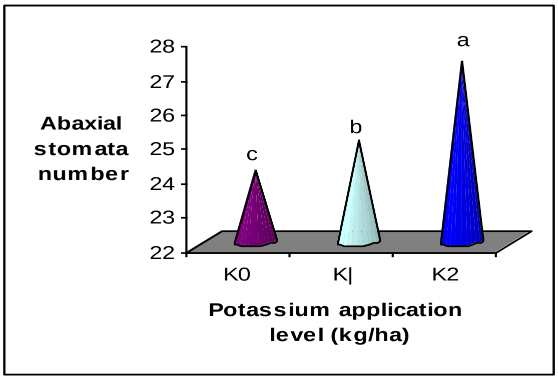

Fig. 6. Effect of potassium application on abaxial stomata number.

Grain yield

In compare with S0, grain yield in S0, S1and S2 decreased 21.41, 46.81 and 59.37%, respectively (Fig. 7). The maximum hollowness in Ismailli cultivar was 5.02%. As well as the maximum hollowness of Airfloure cultivar was 3.84% and its minimum was 1.89 in 210 and 70 mm evaporation from class A pan respectively, which shows significant differences in the reactions to water deficits. Grain yield increased with potassium application enhancement.

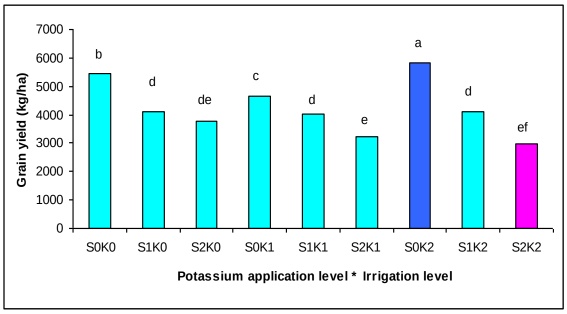

Fig. 7. Effects of potassium application and water deficit on grain yield.

Conclusions

Number of seed per head increased from S0 to S1 irrigation level and after that decreased. With increasing irrigation level head length decreased and grain yield increased. In all potassium application levels, leaf relative water content and number of seeds per head were enhanced in compare with S0, also with increasing irrigation level, except of S0 and S1, leaf water potential followed this trend. In all of potassium application levels stomatal resistance and number of seeds per head in compare with S0 increased with irrigation level enhancement. Except S0 of and S1, under non-application of potassium condition the number of stomata on abaxial side of leaf followed from this trend. Except of S0 in K0, K1: and K2 levels of potassium application and S1 in K1 level, in all of potassium application levels number of stomata on the abaxial side of leaf increased with enhancement of irrigation level. In all potassium application levels leaf area did not follow a total growing or dropping pattern with increasing irrigation level, so that in K0 and K2 levels of potassium application leaf area decreased with increasing irrigation and decreased in K1 and K2 levels.

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