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Evaluation of Water Deficit Stress Effects, Different Rates of Nitrogen and Plant Density on Remobilization, Current Photosynthesis and Grain Yield in Sunflower Var. Iroflor

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Abstract: This experiment was consisted in 2007-2008 and 2008-2009 cropping seasons in field Agriculture and Research center of West-Azerbaijan. The experimental design was split-split-plot experiments using Randomized Complete Block Design (RCBD) with 3 replications. The factor main was consisted irrigation treatment including optimum irrigation, moderate stress and sever stress where irrigation was done after depletion of 50%, 70% and 90% of available water, respectively. Three nitrogen levels consisting of 100, 160 and 220 kg N ha^{-1} were considered as sub plots and sub-sub plots consisted of three plant populations of 5.55, 6.66 and 8.33 plants m^{-2}. The results of combined analyzes showed that severe drought stress reduced the grain yield by 60% compared to the optimum irrigation condition. Comparison of two-year-mean showed that severe drought stress in compared with optimum irrigation dry matter remobilization rate reduced about 30 percent. In level of optimum irrigation with increasing rate of nitrogen dry matter remobilization rate declined and in this condition with increasing plant population dry matter remobilization rate increased. Severe drought stress in compared with optimum irrigation current photosynthesis efficiency reduced about 35 percent. In level of irrigation with increasing rate of nitrogen contribution of remobilization decreased but current photosynthesis contribution increased significantly. In level of irrigation with increasing plant population contribution of remobilization increased but current photosynthesis contribution decreased. Therefore in condition of severe drought stress due to reduction of current photosynthesis rate, current photosynthesis contribution decreased so increasing of contribution of remobilization prevented a mostly from yield reduction.

Key words: Sunflower · Water deficit stress · Nitrogen · Plant population · Remobilization

INTRODUCTION

Iran is a country prone to drought and the rate of drought damage due to decrease per capita water availability resulting from population growth, climate change and over-exploitation of resources quality reducing is increasing [1]. Drought is one kind of environmental stresses which can cause considerable reductions in grain yield, especially during the reproductive stage. Around 30-40% decline in grain yield was documented under mid drought stress, even without harvest under extremely drought stress [2]. Sunflower (*Helianthus annuus* L.) is one of the most important oil seed crops in Turkey. One of the major obstacles to high yield and production is the lack of synchronized crop establishment in sunflower due to poor weather and soil conditions [3]. Drought is one of the non-biological stresses that can affect growth and yield [4]. Jabari *et al*. [4] reported that with increasing drought stress grain yield decreased 83%. Alizadeh *et al*. [5]. showed that drought stress can be reduced remobilization that Cause of it's could be due to two factors, first factor is the photosynthetic capacity of leaves decreased and the second factor is transmission between different plant organs such as stems, leaves and ear has been impaired. Baradaran Firoozabadi *et al*. [6] showed that reduction water availability caused a significant increase in the remobilization that nitrogen fertilizer treatments was more significant This increase caused improvement of harvest index about 10%. Enayat Gholizadeh and Fathi [7] showed that with apply of drought stress the remobilization was equivalent to 414 kg per hectare and in condition of

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optimum irrigation amount of that was equivalent to 483 kg per hectare. Ehdaei *et al*. [8] showed that drought stress increased retranslocation efficiency. Various researchers have shown that with increasing rate nitrogen, grain yield increased [8,9]. Enayat Gholizadeh and Fathi [7] showed that with increasing of nitrogen use, remobilization contribution of photosynthetic material to grain decreased. Dordas and Sioulas [11] expressed that nitrogen fertilizer increased the rate of photosynthesis and reduced remobilization of amount of dry matter. Bohrani and Tahmasebi Sarvestani [12] showed that with increasing fertilizer nitrogen efficiency of remobilization decreased significantly. Taghdiri *et al*. [13] showed that biological and seed yield increased with increasing plant density. Javadi *et al*. [14] showed that with increasing plant density, percent of stem remobilization reduced significantly. Dordas [15] showed that the dry matter remobilization from vegetative tissues were very important for grain development. Fang *et al*. [16] showed that both current assimilation transferred directly to grains and remobilization of assimilates stored in vegetative plant parts contribute to grain yield. Therefore this study to determine remobilization rate of the dry matter, current photosynthesis and traits related to that were performed in different moisture conditions, different rates of nitrogen fertilizer and different plant density in Urmia.

MATERIALS AND METHODS

This experiment was conducted in order to investigate the effects of water deficit stress, different levels of nitrogen and plant density on remobilization, current photosynthesis and grain yield in oily sunflower (Var: Iroflor). It was performed during 2008 and 2009 at the research farm of the Centre of Agriculture and Natural Resources in Orumieh, West-Azerbijan, Iran. The experiment was implemented in a split-split-plot using Randomized Complete Block design with three replications. The main factor was irrigation treatments including optimum irrigation, moderate stress and severe stress. Irrigation was done after depletion of 50, 70 and 90 percent of field capacity, respectively. Three nitrogen levels consisting of 100, 160 and 220 kg N ha-1 were considered as sub plots with sub-sub-plots consisted of three plant densities of 5.55, 6.66 and 8.33 plant m^{-2}. The plant distance on each row was 20, 25 and 30 cm and distance between rows was 60 cm. These spacing were randomly located in the main plots, sub plots and sub-sub plots. Each sub-plot consisted of 7 plant line. Each plant line was 4 meter long. The distance between two sub-plots and two main plots were 1m and 2m, respectively. Thus main plot area was 51.6 m^2 with total area of 2500 m^2. The operations of plough and preparation of farm included a deep plough, two vertical disks, leveling, furrow, mound and plot making. The soil texture was loamy silt clay. The amount of fertilizer added to farm was determined by soil analysis. The planting was done manually after irrigation in 27 may 2008 and 2009. The grains used in this study were Hybrid Iroflor. This hybrid comes from the variety of single-cross and the group of middle ripping and has registered in 1988 in France.

The first irrigation was done in 5 June. The thinning conducted in 4-5 leaf stage. The weeding conducted in 2 stages of 20 and 40 days after planting. Nitrogen fertilizer applied in the form of surplus in 2 stages of 7-8 leafage and flowering time. When downside of head turned to brownish yellow the final harvest was performed. In this stage seeds had 20 percent of moisture. In order to remove the edge effect, the sampling was not conducted from lateral rows. For determining soil moisture samples were taken from 2 depths of soil 0-30 and 30-60 cm in each (Table 1). Then weight moisture percentage was determined by pressure plate (armfield CAT.REF: FEL13B-1 Serial Number: 6353 A 24S98). In this experiment field capacity of soil was determined to be 26 with permanent wilting point of 14. In order to obtain the exact irrigation time, soil was sampled by auger from root development depth in each treatment 48 hours after irrigation to measure soil weight moisture. Based on the measurement, the irrigation time was determined to be at soil weight moisture of 20, 17.6 and 15.2. To implement the irrigation operation the water usage volume was calculated by the following equation 1:

$$V = \frac{(fc - \theta m) \times \rho \times Droot \times A}{Ei} \quad (1)$$

V= Irrigation water volume (m^{-3}) Θm = soil weight moisture percentage irrigation

A= Irrigated area (m^{-2}) FC= field capacity

ρm = soil external specific density (gcm^{-3}) Droot= root development depth (m^{-1})

Therefore the required water volume in each stage of irrigation in each treatment was calculated and was distributed equally based on the water distribution efficiency of 90 percent by flume and chronometer. The final harvesting area was equal to 4.8 m^{-2} that was done from two middle lines of planting. Final measurements

were conducted from these samples. For moisture measurement grains were located in the oven in the temperature of 72 degrees centigrade for 48 hours. In order to evaluate remobilization efficiency and contribution and current photosynthesis seven days after flowering from each plot after removing the effects of lateral margin, five plants were harvested and total dry weight was measured. At the end of plant growth grain yield and related traits were calculated using the relationship.

$$R = Y2\text{-}Y1 \quad (2)$$

R= Remobilization of storage material (kg ha^{-1})
Y2= Dry weight of vegetative organs at Anthesis (kg ha^{-1})
Y1= Dry weight of vegetative organs at Maturity (kg ha^{-1})

$$\text{Remoblizatione efficiency} = \frac{R}{Y_2} \quad (3)$$

$$\text{Remoblizationecontribution} = \frac{R}{Grain\ yeild} \quad (4)$$

$$Current\ photosynyhesis = grain\ yeild - \text{Re}mobilization\ of\ storagematerial \quad (5)$$

$$\text{Current photosynyhesis efficiency} = \frac{\text{Rate of current photosynyhesis}}{\text{Dryweight of vegitativeorgans at Anthesis}} \quad (6)$$

$$\text{Current photosynhesis share} = 100\text{-Remobilization contribution} \quad (7)$$

Analysis of variance was performed using PROC ANOVA of SAS. The comparison of the means was done by Tukey's test at a probability level of 5 percent.

RESULTS AND DISCUSSIONS

Grain Yield: Results of combined ANOVA showed that the effect of drought stress, nitrogen and plant density was significant on grain yield (Table 1). With increasing severe drought stress, grain yield decreased. Mean comparison Two-year showed that the highest and lowest grain yield was related to optimum irrigation and severe drought stress respectively (Table 2, 3). Water deficit reduced leaf area index and impaired nutrient absorption and water absorption materials and transferring photosynthetic material to grain as a result that reduced grain yield. This result confirmed with results of Roshdi *et al*. [17] and Majd Nasiri [18]. Increasing nitrogen application caused grain yield to increase. The consumption of more quantities of fertilizer at optimum irrigation condition caused considerable increase in grain yield whereas at severe drought stress condition using more quantities of nitrogen did not increased grain yield (Table 2). It seems that this situation results from absorption reduction and increasing nitrogen waste due to water deficit in soil. Nitrogen consumption due to the strong sink means more grain and more the source of activity (higher LAI) increased grain yield. Chlorophyll content and leaf area index was increased by increasing nitrogen that this improved the absorption of light and produced more biomass. Consumption of 220 kg nitrogen per ha^{-1} compared with 100 kg nitrogen ha-1 increased grain yield about 16% (Table 2). This result confirmed with results of Dehghan and Jahangiri [19]. Other researchers showed that grain yield increased with increasing nitrogen [9, 10, 20]. Compare the interaction of irrigation and plant density showed that the highest grain yield

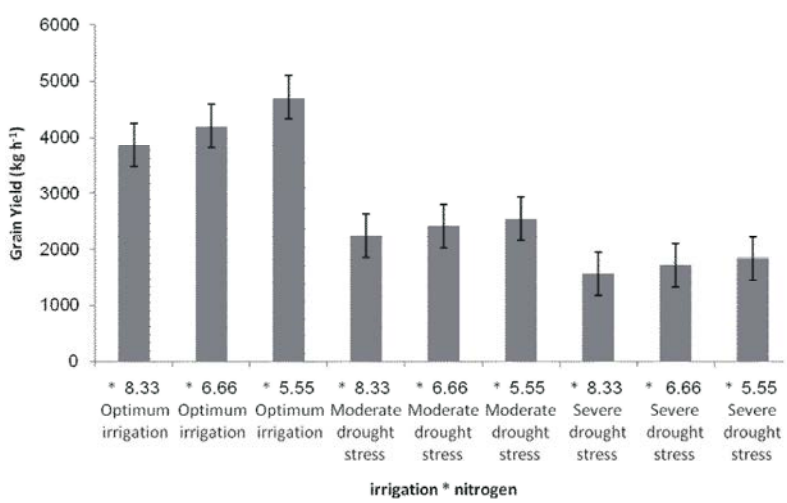

Fig. 1: This graph shows the interaction effect of irrigation different levels and nitrogen fertilizer on grain yield.

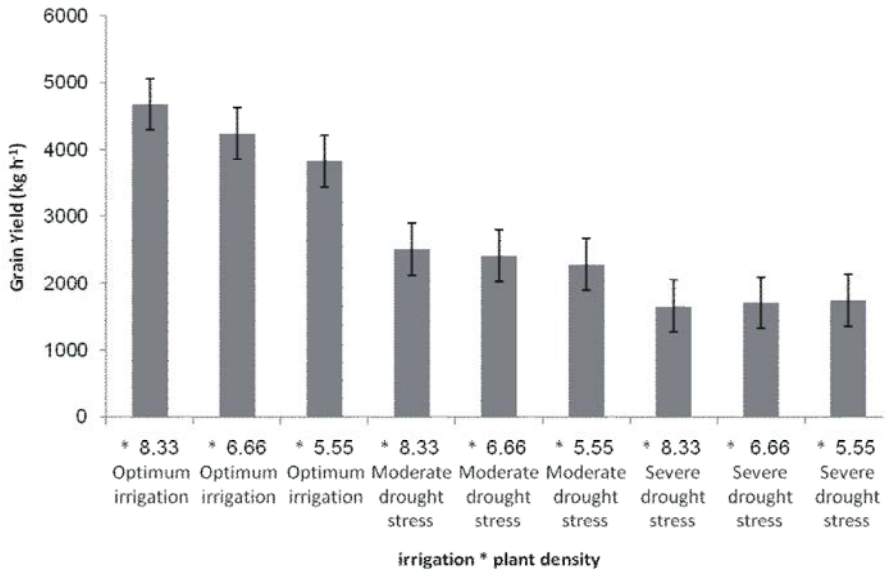

Fig. 2: This graph shows the interaction effect of irrigation different levels and plant density on grain yield.

Table 1: Combined analysis of variance for traits of sunflower in different drought stress, nitrogen and plant population (2008-2009)

S.O.V.	df	Grain yield	Remobilization	Remobilization Efficiency	Remobilization Contribution	Current Photosynthesis	Current Photosynthesis Contribution	Current Photosynthesis Efficiency
Year	1	134098.7**	6479.01**	0.0078**	2.32**	81626.0**	2.32**	0.00000098^{ns}
Irrigation	2	93453380.6**	893157.70**	0.0096**	2862.12**	76368854.7**	2862.12**	0.358**
Year × irrigation	2	25089.1^{ns}	13461.33**	0.0014**	16.53**	69983.0**	16.53**	0.004**
Error 1	8	30538.3	17743.32	0.0072	15.77	25288.1	15.77	0.0036
Nitrogen	2	3046011.2**	57036.56**	0.0055^{ns}	3.93**	2282577.1**	3.93**	0.0029**
Nitrogen ×Year	2	33660.2^{ns}	945.29^{ns}	0.0066^{ns}	18.82**	36690.5^{ns}	18.82**	0.0061**
Irrigation ×nitrogen	4	496110.9**	98140.41^{ns}	0.0051^{ns}	139.92**	1015998.7**	139.92**	0.0223**
irrigation× nitrogen × Year	4	13102.1^{ns}	3347.96^{ns}	0.0047^{ns}	9.40**	26373.1^{ns}	9.40**	0.0012*
Error 2	24	28991.0	799.75	0.005	2.29	25893.8	2.29	0.00056
Density	2	1474373.0**	230311.89**	0.0022^{ns}	92.88**	551807.4**	92.88**	0.093**
density × Year	2	537.4^{ns}	197.99**	0.0035^{ns}	0.09^{ns}	380.9^{ns}	0.090^{ns}	0.00034**
Irrigation ×density	4	1026598.5**	41983.61^{ns}	0.0063^{ns}	9.91**	691652.0**	9.91**	0.0010^{ns}
density × irrigation × Year	4	568.1^{ns}	558.98^{ns}	0.0067^{ns}	1.75**	2220.7^{ns}	1.75^{ns}	0.0013*
density × nitrogen	4	14617.9^{ns}	1252.95^{ns}	0.0051^{ns}	0.75^{ns}	7961.8^{ns}	0.57^{ns}	0.000077^{ns}
density × nitrogen × Year	4	1568.5^{ns}	140.76^{ns}	0.0049^{ns}	0.91^{ns}	2423.5^{ns}	0.91^{ns}	0.00059^{ns}
density × nitrogen × irrigation	8	19019.3^{ns}	2254.59^{ns}	0.0045^{ns}	2.95**	17506.1^{ns}	2.95**	0.00079^{ns}
density × nitrogen × irrigation × Year	8	2171.2^{ns}	353.62^{ns}	0.0049^{ns}	0.73^{ns}	2324.7^{ns}	0.73^{ns}	0.00041^{ns}
Error 3	72	19399.4	991.06	0.0049	0.38	13259.2	0.38	0.00043
CV	-	4.99	4.42	21.42	2.23	5.54	0.86	5.56

**, * and Ns significant at the 1%, 5% probability levels and non significant respectively

Table 2: Combined mean comparison for traits of sunflower in the interaction effect irrigation and nitrogen (2008 -2009)

Treatments (Irrigation × Nitrogen)		Grain yield (Kg ha^{-1})	Current Photosynthesis (Kg ha^{-1})	Current Photosynthesis Efficiency (g g^{-1})
Irrigation	Nitrogen			
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Optimum irrigation	100	3859.6 c	2954.71 c	0.43 c
×	160	4188.5 b	3355.70 b	0.46 b
	220	4707.3 a	3907.30 a	0.49 a
Moderate drought stress	100	2245.6 e	1602.59 d	0.37 d
×	160	2416.1 de	1731.09 d	0.36 d
	220	2547.4 d	1772.96 d	0.32 ef
Severe drought stress	100	1564.7 g	1058.75 e	0.33 e
×	160	1715.4 fg	1122.50 e	0.30 f
	220	1838.5 f	1169.06 e	0.27 g

Means followed by similar letters in each column are not significantly different at the 5% level of probability according to Tukey's Test.

Table 3: Combined mean comparison for traits of sunflower in the interaction effect irrigation and plant density (2008 -2009)

Treatments (Irrigation × Plant density)			Grain yield (Kg ha^{-1})	Current Photosynthesis (Kg ha^{-1})
Irrigation		Plant density		
Optimum irrigation		8.33	4679.7 a	3721.54 a
	×	6.66	4247.4 b	3415.40 b
		5.55	3828.3 c	3080.76 c
Moderate drought stress		8.33	2511.7 d	1726.63 d
	×	6.66	2412.1 de	1725.83 d
		5.55	2285.3 e	1654.18 d
Severe drought stress		8.33	1661.3 f	1059.16 e
	×	6.66	1709.5 f	1121.70 e
		5.55	1747.7 f	1169.45 e

Means followed by similar letters in each column are not significantly different at the 5% level of probability according to Tukey's Test.

Table 4: Combined mean comparison for traits of sunflower in the interaction effect irrigation, nitrogen and plant density (2008 -2009)

			Remobilization (Kg ha^{-1})			Remobilization Contribution (%)			Current Photosynthesis Contribution (%)		
Treatments (Irrigation × Plant density)			Optimum irrigation	Moderate drought stress	Severe drought stress	Optimum irrigation	Moderate drought stress	Severe drought stress	Optimum irrigation	Moderate drought stress	Severe drought stress
Nitrogen (Kg ha^{-1})		Plant density (plants m^{-2})									
		8.33	1010.35 a	710.53 fgh	524.43 lm	23.75 l	30.30 gh	34.28 bc	76.25 c	69.70 gh	65.71 lm
100	×	6.66	893.330 b	629.41 ijk	495.56 m	23.28 l	27.88 ijk	31.83 ef	76.71 c	72.11 def	68.16 ij
		5.55	811.06 de	589.30 kl	497.90 m	23.15 l	27.65 jk	31.00 fg	76.85 c	72.35 de	69.00 hi
		8.33	937.15 b	754.63 def	617.60 ijk	20.50 m	29.80 gh	36.88 a	79.50 b	70.20 gh	63.11 n
160	×	6.66	819.18 cd	684.88 fghij	587.95 kl	19.56 m	28.25 ijk	34.13 bcd	80.43 b	71.75 def	65.86 klm
		5.55	742.28 efg	615.36 jk	573.38 kl	19.51 m	26.88 k	32.80 de	80.48 b	73.11 d	67.20 jk
		8.33	927.00 b	890.08 bc	664.46 hij	17.73 n	33.41 cd	37.41 a	82.26 a	66.58 kl	62.58 n
220	×	6.66	783.68 de	744.66 efg	680.10 ghij	16.58 n	29.21 hi	36.81 a	83.41 a	70.78 fg	63.18 n
		5.55	689.38 fghi	688.66 fghi	663.73 hij	16.61 n	28.36 ij	35.23 b	83.38 a	71.63 ef	64.76 m

Means followed by similar letters in each column are not significantly different at the 5% level of probability according to Tukey's Test.

(4679.70 kg ha^{-1}) obtained the highest density (8.33 plants m^{-2}) and optimum irrigation (Table 4). Severe drought stress compared with optimum irrigation decreased grain yield 60 percent. Increasing number of plants per area was accompanied with considerable increase in grain yield (Table 3). Many researchers have pointed to grain yield increase due to increasing plant density [21, 22]). The most grain yield of about 4628.7 kg ha-1 obtained from the highest density at optimum irrigation treatment but in moderate and severe drought stress conditions yield increase due to the increase of density was not significant. These results are showing that the use of high densities can be useful at optimum condition. Askandar Torbaghani and Askandar Torbaghani [23] reported that with decreasing plant density, grain yield decreased. In low densities grain yield was low due to decreasing the number of plants per area and increasing nitrogen was effective to some extent due to the limitation in capacity of each plant to use nitrogen and therefore extra nitrogen was not used and remained out of plant access. By plant density increase, grain yield per area unit became more due to the increase in the number of plants per area.

Remobilization of Storage Materials And Current Photosynthesis: The results of combined analysis of variance showed that the effect of irrigation different levels, nitrogen usage, plant density, the interaction effect irrigation and nitrogen, the interaction effect irrigation and plant density on rate of remobilization and Current Photosynthesis was significant at probability level 1%. Also the interaction effect irrigation × nitrogen × plant density had significantly effect on rate of remobilization at probability level 5% (Table 1). Mean comparison Two-year showed that with increasing severe drought stress, rate of remobilization decreased significantly. Severe drought stress compared with optimum irrigation decreased rate of remobilization about 30 percent. At level of optimum irrigation with increasing nitrogen usage, rate of remobilization decreased significantly but at level of nitrogen usage with increasing plant density rate of remobilization increased significantly in optimum irrigation condition. The highest (1010.35 kg ha^{-1}) and lowest (689.38 kg ha^{-1}) rate of remobilization obtained from treatments of 100 kg N per ha^{-1} × 8.33 plants m^{-2} and 220 kg N per ha^{-1} × 5.55 plants m^{-2} respectively (Table 4).

At levels of severe and moderate drought stress, increasing nitrogen improved rate of remobilization. At each level of nitrogen, with increasing plant density, rate of remobilization increased significantly but at level of 220 kg N per ha^{-1} significant differences didn't observed in severe drought stress conditions. The highest (890.08 kg ha^{-1}) and lowest (589.30 kg ha^{-1}) rate of remobilization obtained from treatments of 220 kg N per ha^{-1} × 8.33 plants m^{-2} and 100 kg N per ha^{-1} × 5.55 plants m^{-2} respectively in moderate drought stress conditions (Table 4). The highest (680.10 kg ha^{-1}) and lowest (495.56 kg ha^{-1}) rate of remobilization obtained from treatments of 220 kg N per ha^{-1} × 6.66 plants m^{-2} and 100 kg N per ha^{-1} × 6.66 plants m^{-2} respectively in severe drought stress conditions also in this conditions significant differences had not between different plant density (Table 4). In general in optimum irrigation, upper levels of nitrogen due to production more LAI and LAD also more current photosynthesis rate of the remobilization was low thus remobilization contribution in production of grain yield decreased. In stress condition especially moderate drought stress Greater amounts of nitrogen compared with lower nitrogen caused to increase due to production more LAI and increasing storage materials at stem rate of remobilization (Table 4). Also attention to that there is not significantly between different plant densities about rate of remobilization therefore, to reduce costs can be considered the lowest plant density (Table 4). The reason of increasing rate of remobilization with increasing plant density was increasing production of photosynthetic materials and constraints of physiological destinations that ultimately increased photosynthesis allocation and remobilization to grain. This result was consistent with results of Enayat Gholizadeh and Fathi [7] and Shokri *et al*. [24]. Mean comparison Two-year showed that with increasing severe drought stress, rate of current photosynthesis decreased significantly. In each level of irrigation treatment with increasing amount of nitrogen, rate of current photosynthesis increased significantly. The highest (3907.30 kg ha^{-1}) and lowest (1058.75 kg ha^{-1}) rate of current photosynthesis obtained from treatment optimum irrigation × 220 kg N per ha^{-1} and severe drought stress × 100 kg N per ha^{-1} respectively (Table 2). Mean comparison the interaction effect irrigation and plant density showed that in each level of optimum irrigation and moderate drought stress, with increasing plant density, rate of current photosynthesis increased significantly but in severe drought stress treatment with increasing plant density, rate of current photosynthesis decreased. The highest (3721.54 kg ha^{-1}) and lowest (1059.16 kg ha^{-1}) rate of current photosynthesis obtained from treatment optimum irrigation × 8.33 plants m^{-2} and severe drought stress × 8.33 plants m^{-2} respectively (Table 2). Severe drought stress treatment compared with optimum irrigation, rate of current photosynthesis decreased about 68%. The reason of rate of current photosynthesis reduction with increasing severe drought stress was decreasing LAI and LAD. Alizadeh *et al*. [5] showed that caused to decrease significantly rate of current photosynthesis that confirmed with this research. Because increasing rate of current photosynthesis with increasing nitrogen flow was the positive effect of nitrogen on LAI, LAD and production and accumulation of dry matter in optimum irrigation conditions. Drdas and Sioulas [11] reported that nitrogen fertilizer increased rate of current photosynthesis but decreased rate of remobilization. Using plant density in severe drought stress condition decreased rate of current photosynthesis and yield dependent was more on the materials related to the remobilization (Table 4) the reason of that yellowing of leaves due to stress and aging rapidly, especially in high densities. Tahmasebi Sarvestani *et al*. [25] showed that with increasing plant density, photosynthetic rate and production increased. Also attention to that there is not significantly between different plant densities about rate of current photosynthesis therefore, to reduce costs can be considered the lowest plant density (Table 3). Correlation between rate of remobilization and grain yield was positive. Table of correlation coefficients showed that between rates of remobilization with dry weight of vegetative organs at Anthesis, dry weight of vegetative organs at maturity, rate of current photosynthesis and grain yield was significant positive correlation (Table 5).

Remobilization and Current Photosynthesis Efficiency: The results of combined analysis of variance showed that the effect of irrigation different levels, nitrogen usage, plant density and all interaction effects was not significant on remobilization efficiency. The effect of irrigation different levels, nitrogen usage, plant density, the interaction effect irrigation and nitrogen, the interaction effect irrigation and plant density on Current Photosynthesis efficiency was significant (Table 1). Mean comparison Two-year showed that with increasing severe drought stress, Current Photosynthesis efficiency decreased significantly. Severe drought stress compared with optimum irrigation decreased Current Photosynthesis efficiency about 35 percent. The lowest (0.27 g g^{-1}) current photosynthesis efficiency obtained from treatment

severe drought stress × 220 kg N per ha^{-1} (Table 3). The reason of reduction of Current Photosynthesis efficiency was decreasing LAI and LAD. Obairi *et al*. [28] showed that severe drought stress caused to decrease significantly grain yield, rate of current photosynthesis, current photosynthesis contribution and current photosynthesis efficiency that confirmed this research. Unlike drought stress, nitrogen consumption caused to increase current photosynthesis efficiency. The reason of rising Current Photosynthesis efficiency with increasing nitrogen consumption was further supply materials for production grain yield (Table 2). In each level of irrigation rising nitrogen consumption increased Current Photosynthesis efficiency. Daneshvar *et al*. [27] showed that with applying nitrogen growth and duration of plant parts increased and caused to increase Current Photosynthesis efficiency. With increasing plant density, Current Photosynthesis efficiency decreased. The highest (0.41 g g^{-1}) and lowest (0.33 g g^{-1}) Current Photosynthesis efficiency obtained from treatments of 5.55 plants m^{-2} 8.33 and 8.33 plants m^{-2} respectively (Table 3). Plant density of 5.55 plants m^{-2} compared with plant density of 8.33 plants m^{-2} increased Current Photosynthesis efficiency about 20%. Reducing Current Photosynthesis efficiency at high plant densities despite the increase in the rate of current photosynthesis due to higher production of dry matter at anthesis has been. These results were consistent with results Bohrani and Tahmasebi Sarvestani [12]. Table of correlation coefficients showed that between current photosynthesis efficiency with dry weight of vegetative organs at Anthesis, dry weight of vegetative organs at maturity, rate of remobilization, rate of current photosynthesis, current photosynthesis contribution and grain yield was significant positive correlation and with remobilization efficiency and contribution was significant negative correlation (Table 5).

Remobilization and Current Photosynthesis Contribution at Grain Yield: The results of combined analysis of variance showed that the effect of irrigation different levels, nitrogen usage, plant density and all interaction effect on remobilization contribution and current photosynthesis contribution was significant (Table 1). Mean comparison Two-year showed that with increasing severe drought stress, remobilization contribution increased significantly but current photosynthesis contribution decreased (Table 4). At level of irrigation treatment with increasing nitrogen usage, remobilization contribution decreased significantly but current photosynthesis contribution increased significantly. At level of irrigation treatment with increasing plant density, remobilization contribution increased significantly but current photosynthesis contribution decreased significantly. The highest (83.41%) and lowest (62.58 %) rate of remobilization obtained from treatments of optimum irrigation and severe drought stress respectively (Table 4). Mean of remobilization contribution at grain yield in optimum irrigation and severe drought stress condition was 20.07% and 34.48% respectively (Table 4). Due to between treatments of 220 kg N per ha^{-1} × 5.55 plants m^{-2} and 160 kg N per ha^{-1} × 5.55 plants m^{-2} and in condition of moderate and severe drought stress, significant difference had not for current photosynthesis contribution therefore, to reduce costs can be considered nitrogen consumption 160 kg N per ha^{-1} (Table 4). Severe drought stress compared with optimum irrigation decreased Current Photosynthesis contribution about 40 percent. The reason of reduction of Current Photosynthesis contribution was decreasing LAI, LAD and senescence and yellowing rapidity of leaves that caused to decrease Current Photosynthesis contribution and more dependent grain yield to remobilization. Severe drought stress compared with optimum irrigation, Current Photosynthesis contribution about 19 percent improved.

Table 5: Matrix of simple correlation coefficient among different traits

	Remobilization	Remobilization Efficiency	Remobilization Contribution	Current Photosynthesis	Current Photosynthesis Contribution	Current Photosynthesis Efficiency	Grain yield
Remobilization	1						
Remobilization Efficiency	0.23^{ns}	1					
Remobilization Contribution	-0.67**	0.38*	1				
Current Photosynthesis	0.82**	-0.37*	-0.94**	1			
Current Photosynthesis Contribution	0.67**	-0.38*	-0.99**	0.94**	1		
Current Photosynthesis Efficiency	0.38**	-0.28^{ns}	-0.89**	0.73**	0.89**	1	
Grain yield	0.86**	-0.36^{ns}	-0.93**	0.99**	0.92**	0.70**	1

**, * and Ns significant at the 1%, 5% probability levels and non significant respectively.

The results of Ahmade *et al*. [28] showed that remobilization contribution of wheat in grain yield in condition of optimum irrigation was 19.3% while in severe drought stress condition was 24.4 and was consistent with these results. With increasing nitrogen, remobilization contribution decreased but Current Photosynthesis contribution increased (Table 5). The reason of rising Current Photosynthesis contribution with increasing nitrogen consumption was further biomass and rate of current photosynthesis. Enayat Gholizadeh and Fathi [7] showed that increasing nitrogen consumption cause to decrease remobilization and rising current photosynthesis contribution. With increasing plant density, remobilization contribution increased that its reason production of further rate of remobilization, reducing Current Photosynthesis contribution due to more respiration of dense plants, be low Supply of light into the canopy and yellowing rapidity of leaves (Table 4). Table of correlation coefficients showed that between current photosynthesis contribution with dry weight of vegetative organs at Anthesis, dry weight of vegetative organs at maturity, rate of remobilization, rate of current photosynthesis, current photosynthesis efficiency and grain yield was significant positive correlation and with remobilization contribution was significant negative correlation (Table 5). Also between remobilization contribution and grain yield there was a significant negative correlation (0.93^{**}) (Table 5).

CONCLUSIONS

Different levels of Water deficit stress, nitrogen and plant density had different effects on plant. By increasing severe drought stress, grain yield, current photosynthesis, current photosynthesis contribution decreased but remobilization contribution increased. By increasing nitrogen fertilizer from 100 to 220 kg nitrogen ha-1 all the aforementioned traits increased significantly except remobilization and remobilization contribution because of increasing current photosynthesis. With plant density increase traits of plant density, grain yield and current photosynthesis increased too but in condition of drought stress increasing plant density had not significantly effect on grain yield because of competition of plants for absorbing water that in this condition water was very low for a lot of plants. Therefore, at optimum irrigation condition for planting sunflower var. Iroflor fertilizer treatment of 220 kg nitrogen ha-1 and plant density of 8.33 plants per m-2 and at drought stress condition fertilizer treatment of 160 kg nitrogen ha-1 and density of 5.55 plants per m-2 is recommended. In other words, the plant density, nitrogen and irrigation should be considered.

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