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Effect of water deficit stress on yield and yield components of canola (*Brassica napus* L.) cultivars

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Abstract

Water deficit stress considered as one of the most important limiting factors for canola (*Brassica napus* L.) growth and productivity in Iran. A factorial experiment on the basis of RCB design with three replications was conducted in 2010, to evaluate the effects of water deficit stress (I_1, I_2 and I_3) on yield and yield components of canola cultivars. Canola cultivars, including 'Hyola 308', 'Amica', 'Heros' and 'Sarigol' as first factor, and the second factor was two levels of water deficit stress, including I_2 (100mm), I_3 (125mm) and normal irrigation (I_1= 75mm) evaporation from class A pan. Results indicated that the interaction between water deficit stress and cultivars affected yield, grain per pod, pod per plant and length pod ($p \leq 0.01$). 'Hyola 308' and 'Sarigol' showed highest and lowest yields under stress conditions. In addition, water deficit stress reduced biological yield, harvest index, and yield components in the two stress levels studied. Further the highest reduce of traits were at I_1 to I_2. In general, 'Hyola 308' and 'Sarigol' can be the most tolerant and sensitive related to the other cultivars, respectively.

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Introduction

In a large part of the agricultural areas in the world, water deficit is an important factor limiting growth and productivity of the crops (Borsani *et al.*, 2001; Micheletto *et al.*, 2007). To survive against the stress, plants have involved a number of morphological, physiological and biochemical responses (Xiong *et al.*, 2006; Gao *et al.*, 2008). The effect of drought stress on growth and yield depends on function of cultivar, duration of stress, weather conditions, growth, and developmental stages of crops (Robertson and Holland, 2004).

Canola is one of the most important oil crops in the world (Bybordi, 2010). The meal that remains after oil extraction has value as a source of protein for the livestock feed industry (Jensen *et al.*, 1996). In Iran and some of other countries, the production of the canola plant is limited by soil salinity and drought. Therefore, development of varieties or selections with increased drought tolerance is of prime importance for growing this economical plant in regions where water is limited. Understanding the biochemistry and physiology of canola adaptation to water stress will help develop varieties with enhanced stress tolerance. The water deficiency can influence inversely the grain of canola but this effect depends on the cultivar, growth stage and the plant adaptation to the drought (Azizi *et al.*, 1999). Ghobadi *et al.* (2006) indicated that the effect of water deficit during reproductive growth was more than that during vegetative growth of canola. Size of canola seed is increased in the water deficiency stress as a compensatory reaction against the reduction of number seed per pods and the level of seed glucosinolate is increased. The water deficiency has the greatest effect on the grain yield of canola in flowering and pollination stage (Fernandes, 1992). The objective of this research was to evaluate the response of canola cultivars against the drought stress.

Materials and methods

Experimental design and Plant materials

This research was carried out at the Research Farm of Payame Noor University of Mahabad, Iran (latitude 36.46°N, longitude 45.43°E, Altitude 1385 m above sea level) in 2010. The climate is characterized by mean annual precipitation of 330 mm, mean annual temperature of 12˚C. The experimental design was factorial on the basis of randomized complete block in three replicates, with the irrigation treatment (I_1=75 mm, I_2=100, I_3=125) in first factor and canola cultivars (Hyola308, Sarigol, Amica, Heros) in second factor. All plots were irrigated after sowing and subsequent irrigations in beginning stem elongation were carried out after 75 (I_1), 100 (I_2) and 125 (I_3) mm evaporation from class A pan. Each plot consisted of one meter rows and plants in the row spaced 20 cm apart. Weeds were controlled by hand during crop growth and development.

Traits measurement and Data analysis

Yield, component yield, biological yield and harvest index percent traits were evaluated. All data were analyzed using the MSTATC and SPSS version 16.0. When ANOVA showed significant treatment effects, Duncan's multiple range tests was applied to compare the means at $p < 0.05$. Excel software was used to draw figures.

Results and discussion

Analysis of variance of the data for yield and yield components showed that 100 grain weight, grain per pod, length pod, pod per plant, yield per unit area, biomass and harvest index were significantly affected by irrigation and cultivar. The interaction of irrigation × cultivar for grain per pod, length pod, pod per plant, yield were significant (Table 1).

In all tested cultivars, water stress reduced 100-weight grain (Fig. 1, a). Highest 100-grain weight amount in 'Hyola 308' (9.16 g $plant^{-1}$) of control condition and lowest amount of 100-grain weight (2.66 g $plants^{-1}$) in 'Sarigol' cultivar in stress conditions of I3 was seen. Among different levels of stress condition, water deficit stress at I1 to I2, showed the lowest impact in reducing the 100-grain weight in three cultivars. In the control condition (I1), most 100-grain weight obtained in 'Hyola 308' and 'Heros' respectively. Among the tested cultivars in this experiment, 'Hyola 308' showed minimum reduction in the 100-grain weight that can be cause of more tolerance of this cultivar to drought stress. Lowest rate of yield (g plant^{-1}) in stress conditions at I2 and I3 in 'Sarigol' and the highest in the normal condition of irrigation (I1) at 'Hyola 308' were obtained (Fig.2, c and Table.2). Therefore, in I1, most yield of cultivar was in 'Hyola 308' and 'Heros'. In I2 most yield (19.15g plant^{-1}) was in 'Hyola 308'and 'Heros' (10.21 g plant^{-1}), in I3 was in 'Hyola 308, and 'Heros' and in the control treatment (I1) most yield was observed in 'Hyola 308' and 'Heros' respectively. Rashidi *et al.* (2012) reported that reason of grain yield reduction in different cultivars can be due to level of used stress and its effect on some yield components such as pod per plant, seed per pods and the weight of thousand seed.

Table 1. Analysis of variance of the data for yield and yield components of canola cultivars under different irrigation treatment.

Source	df	Grain per pod	Length pod (cm)	Pod per plant	100-grainweight (g/plant)	Yield	Biological yield	% Harvest index
Replication	2	1.361	0.04	6.69	0.006	1.76	0.42	23.65
Irrigation	2	98.11**	7.52**	21538.52**	26.62**	732.23**	156.34**	7817.41**
Cultivar	3	62.91**	3.23**	54.67.88**	17.52**	354.33**	129.79**	3071.19**
G*I	6	2.33*	0.17**	269.15**	0.203	9.43**	2.76	51.67
Error	22	0.84	0.01	7.755	0.11	1.49	1.09	22.55
CV%		7.58	2.94	2.06	5.87	10.39	4.37	10.66

*,** Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Table 2. Compare means between treatment and interaction effects.

	100-grain weight	Biological yield (gplant^{-1})	Grain per pod	Length pod (cm)	Pod per plant	Yield (gplant^{-1})	%Harvest index
Irrigation							
I1	7.33 a	27.58 a	14.75 a	4.80 a	181 a	20.25 a	71.94 a
I2	5.70 b	23.82 b	12.58 b	3.87 b	127.2 b	10.15 b	40.31 b
I3	4.35 c	20.37 c	9.08 c	3.23 c	97.42 c	4.88 c	21.43 c
Cultivars							
Hyola308	7.67 a	29.08 a	15.22 a	4.72 a	164.9 a	20.24 a	67.9 a
Sarigol	4.35 d	20.14 d	8.88 d	3.18 d	106.3 d	5.44 d	23.91 d
Amica	5.32 c	22.38 c	11.56 c	3.78 c	127.4 c	9.25 c	38.27 c
Heros	5.84 b	24.09 b	12.89 b	4.08 b	142.1 b	12.12 b	48.16
Interaction							
I1× Hyola308	9.16 a	32.33 a	16.67 a	5.2 a	198.3 a	30.22 a	93.6 a
Sarigol	5.73 d	24.997 cd	12.33 d	4.43 d	165.7 d	11.72 d	46.9 d
Amica	6.93 b	26.17 c	14.33 bc	4.7 c	176 c	17.48 c	66.82 c
Heros	7.5 b	26.87 bc	15.67 ab	4.9 b	184 b	21.6 b	80.44 b
I2 × Hyola308	7.5 b	28.53 b	15.67 ab	4.83 bc	163 d	19.15 c	67.10 c
Sarigol	4.66 ef	19.53 fg	8.66 e	3.03 h	91.33 h	3.69 f	18.94 f
Amica	5.2 de	22.97 e	12.33 d	3.63 f	118 f	7.56 e	32.94 e
Heros	5.46 d	24.23 de	13.67 cd	4 e	136.3 e	10.21 d	42.27 d
I3× Hyola308	6.36 c	26.37 c	13.33 d	4.13 e	133.3 e	11.34 d	42.99 d
Sarigol	2.66 h	15.93 h	5.66 f	2.4 i	62 i	.93 g	5.87 g
Amica	3.83 g	18 g	8 e	3.03 h	88.33 h	2.707 fg	15.05 f
Heros	4.56 f	21.17 f	9.33 e	3.36 h	106 g	4.54 f	21.79 f

Different letter in each column indicate significant difference at $p \leq 0.05$.

I1, I2, I3: 75mm, 100 mm and 125 mm evaporation from class A pan, respectively.

Lowest rate of biological yield in stress conditions in (I3) of the 'Sarigol' cultivarand the highest amount in the normal conditions (I1) of 'Hyola 308' was observed (Fig.1, b and Table.2). In I1and I2 most biological yield was in 'Hyola 308'cultivar. In the third level of stress (I3), highest biological yield in 'Hyola 308'and 'Heros' respectively evaluated. Xiong *et al*. (2006) reported that the number of grains per plant was directly proportional to the crop biological yield. Generally, the drought stress reduce, canola grain yield (Jensen *et al*., 1996). Results showed that there was a significant difference between the different cultivars in terms of harvest index. The highest harvest index was in normal conditions (Fig. 2, a).

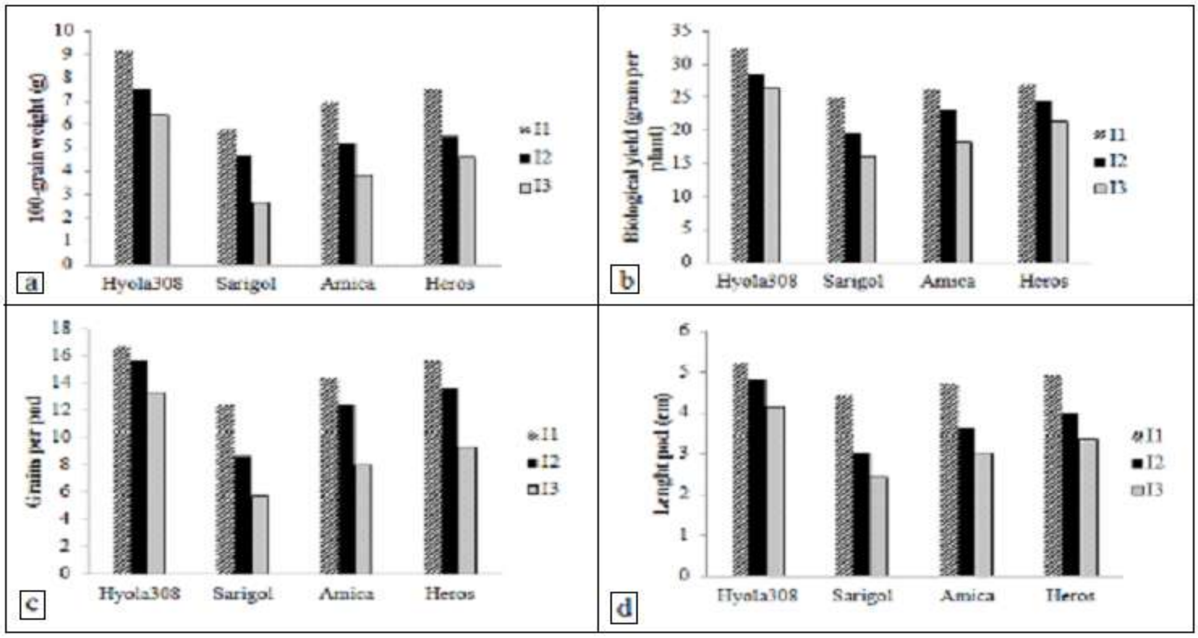

Fig. 1. Interaction of cultivars and water stress on 100-grain weight (a), biological yield (b), grain per pod (c). grain per pod and length pod (d).

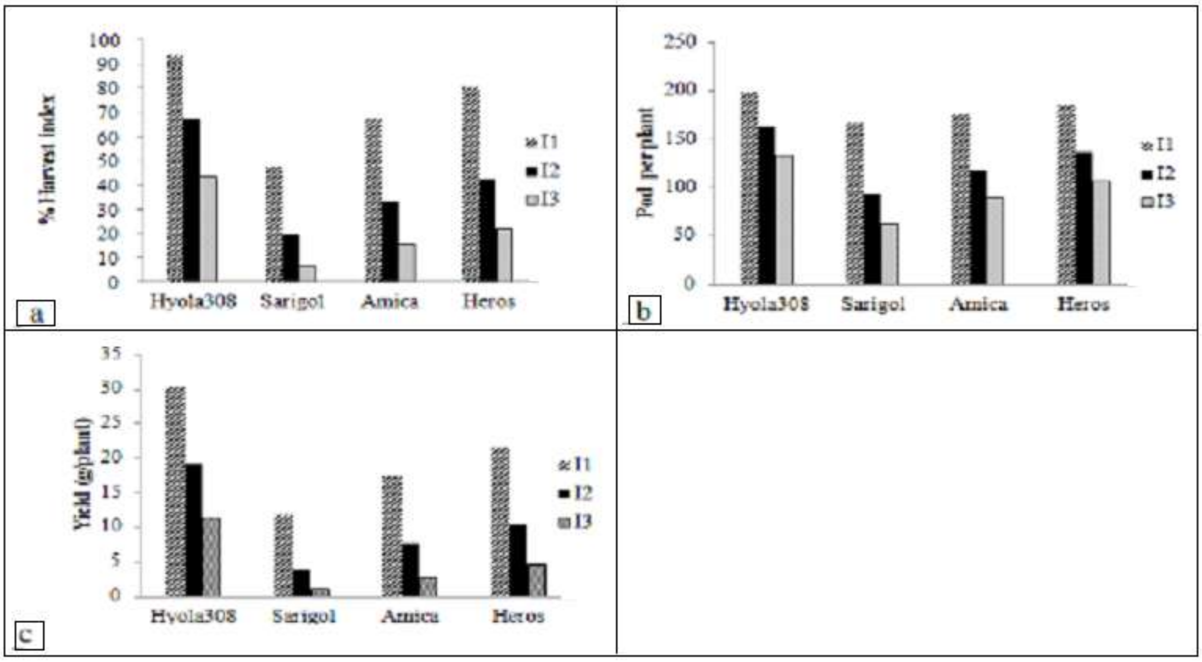

Fig. 2. Interaction of cultivars and water stress on harvest index (a), pod per plant (b)-and yield (c).

Highest harvest index was in 'Hyola 308' and in the control condition (93%) and the lowest in 'Sarigol' at stress conditions in I3 (5.88%). The effect of stress on harvest index at I3 was greater than I2. The result of harvest index decrease during stress is compatible with Turk *et al.* (1980) results. They concluded that, due to stress and water deficiency, certainly the transmission of photosynthetic substances to shoot organs decrease and, in the end, yield components are reduced. Indeed, with the reduction of these components, the harvest rate index decreases. Also the results indicated that there were significant differences among cultivars different levels of stress and their interactions on pod length (Fig.1, d), pod per plant (Fig.2, b) and grain per pod (Fig. 1, c). The highest and lowest amount of pod length, pod per plant and grain per pod was in 'Hyola 308' and 'Sarigol' under normal and stress conditions. In general, results of this study are in accordance with Tohidi-Moghadam *et al.* (2009). Water disruption during flowering and grain filling stages may increase flower and pod abortion, thus decreasing the grain number per plant. Similar results were reported for chickpea (Ghassemi-Golazani *et al.*, 2008), soybean (Demirates *et al.*, 2010).

Conclusion

Water deficit during productivity stage can lead to severe loss in yield and yield components of canola cultivars. According to this experiment Hyola 308 is a high yielding cultivar under well and limited irrigation conditions.

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