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The effects of water deficit stress on seed yield and quantitative traits of Canola cultivars

Ghasemali Nazemi[1]* and Abolghasem Alhani[2]

1. Department of Plant Production, Haji abad Branch, Islamic Azad University, Haji abad, Iran
2. The Agricultural Research Institute of Darab, Iran

Corresponding author: Ghasemali Nazemi

ABSTRACT: Concerning the importance of oilseeds cultivation, especially canola in addition to the growing trend of its cultivated land and limited water resources in the world, this experiment was undertaken in split plot based on randomized complete block design (RCBD) with four replications in order to evaluate the effects of the water deficit stress on seed yield and quantitative traits of canola cultivars to determine the tolerant and sensitive cultivars. The main plots included two canola cultivars (RGS003 and Sarigol) and sub plots were five irrigation levels including; I_1, irrigation during full season (control); I_2, water deficit stress in stemming stage; I_3, water deficit stress in budding stage; I_4, water deficit stress in flowering stage and I_5, water deficit stress in ripening stage. Mentioned treatments were selected in order to evaluate the canola relative resistance to water deficiency in these stages. During conducting the experiment, important traits of canola cultivars were measured including plant height, number of branches per plant, number of siliqua per plant, seed yield and volume of the consumed water in all irrigation treatments for both Sarigol and RGSoo3 cultivars. The highest water consumption efficiency was obtained for the cv. RGS003 and from water deficit stress treatment in ripening stage that was 0.682 ha^{-1}, while the least water consumption efficiency rate was 0.482 ha^{-1} for the cv. Sarigol and from water deficit stress in flowering stage. The interaction effect of irrigation and canola cultivars indicated that the most seed yield reduction from water deficit stress was in budding stage and for cv. Sarigol was 2858 kg ha^{-1}. So, the overall performance of the cultivars for seed yield indicates that under water deficit stress, the cv. RGS003 is superior to other cultivar. Hence, it can withstand low levels of water regimes.

***Keywords*:** Canola cultivars, Water deficit stress, Seed yield

INTRODUCTION

Canola (*Brassica napus* L.) is one of the most important oilseeds both in Iran and throughout the world. In recent years because of paying more attention to the development and cultivation of canola its cultivation area has increased significantly. The special characteristics of this plant and its adaptation to different climatic conditions have increased the importance of this plant. Because of our country climate, arid and semi-arid, water deficit is one of the main barriers for developing cultivation level and caused decreasing yield in this crop (Omidi, 2005) and also water deficit stress considered as one of the most important limiting factors for oil seed canola growth and productivity in Iran (Hosseini and Hassibi, 2011).

Increasing yield per unit and selection of resistance variety to water deficit stress tolerance is the main purpose of crop plant breeding that evaluates plants growth and establishment during growth stage in order to select drought resistant variety (Singh, 1996). In the water deficit condition, tolerance varieties having more ability for adapting that this is excellent factor for them. Improvement of productivity of rapeseed genotypes under drought stress has rarely been included in breeding programs (Cheema and Sadaqat, 2004). Jensen, (1996) reported that the water deficit stress in vegetative growth and flowering stages didn't have significant effect on each canola weight. However, during water shortage in seed filling stage their weight reduce. It has shown that supplemental irrigation of canola increases the number of pods and seeds per pod by extending flowering stage.

Nasri, (2008) observed that applying drought stress caused a significant reduction in the number of siliqua per plant, the number of seeds per siliqua, 1000-seed weight, seed yield, the seed oil content, and the oil yield of five canola cultivars. Results from experiments conducted by Sinaki, (2007) revealed that water deficit stress during the flowering stage until the maturity of 29 canola cultivars resulted in the reduction of seed yield, the biological yield, and the number of siliqua per plant; however, the number of seeds per siliqua was not affected.

Ability of improving canola cultivars that able to maximum use of existing water and drought tolerant is the main objectives of increasing seed yield potential in semi-arid and dry areas. In fact, identification of drought-tolerant cultivars and developing them are among the main economic goals in the regions where water is considered a limiting factor and the study of agronomical adaptations of canola to water deficit stress could lead to identifying and developing stress-tolerant cultivars. Concerning the importance of oilseeds cultivation, especially canola in Iran in addition to the growing trend of its cultivated land and limited water resources in the country, this study was undertaken with the purpose of identifying drought-tolerant canola cultivars based on their seed yield and also to eliminate the numbers of irrigation times in canola planting without significant reduction of the yield.

MATERIALS AND METHODS

In order to evaluate the effects of the water deficit stress on seed yield and quantitative traits of canola cultivars to determine the tolerant and sensitive cultivars, an experiment was carried out in split plot based on randomized complete block design (RCBD) with four replications in Darab, Iran. The main plots included two Canola varieties (RGS003 and Sarigol) and sub plots were five irrigation levels including; I_1, irrigation during full season (control); I_2, water deficit stress in stemming stage; I_3, water deficit stress in budding stage; I_4, water deficit stress in flowering stage and I_5, water deficit stress in ripening stage. Mentioned treatments were selected in order to evaluate the canola relative resistance to water deficiency in these stages.

Statistical society was considered 40 individual experimental plots that each plot consisted of 4 rows, 3m long and a row spacing of 30 cm and planted area of $6m^2$. Soil moisture of experience was in field capacity and constant withered point determined with field measurements. To apply irrigation treatments, the soil samples were taken from 0-30, 30-60 and 60-90 cm depths and their weighted moisture was measured in laboratory. Water amounts calculated from this method was given to the related experimental plots by valve tubes irrigation system. During conducting the experiment, important traits of canola cultivars were measured including plant height, number of branches per plant, number of siliqua per plant, seed yield and volume of the consumed water in all irrigation treatments for both Sarigol and RGSoo3 cultivars. The collected data were analyzed by the analysis of variance (ANOVA) technique to determine significant differences using M-STATC software and Duncan's multiple range test was applied for mean separation when F values were significant.

RESULTS AND DISCUSSION

During our investigation, the analysis of variance showed that canola varieties as the main plots had significant difference in number of branches per plant, number of siliqua per plant, seed yield but these results haven't shown significant effects in plant height (Table 1). Sadaqat, (2003) have reported a significant decrease in the plant height of canola cultivars under water stress conditions.

Irrigation treatments as the sub plots led to a significant difference for all of traits. Also, the interaction effect of irrigation and cultivar showed significant differences among all of traits except the seed yield. These results have been reported in Table 1. The coefficient of variation (CV) is defined as the ratio of the standard deviation to the mean of trait and ranged from 1.99 to 12.03 percent among traits (Table 1).

The seed yield was measured by harvesting 6 m^2 of the central part of each plot at crop full maturity. The results of mean comparisons indicated that there was significant difference between Canola cultivars in this trait and cv. RGSoo3 with average 3803 kg ha^{-1} was superior (Table 2). Indeed, the mentioned difference between canola cultivars in terms of this trait could be caused by their genetic differences (Asgari and Moradi Dalini, 2007). The effects of various treatments of irrigation showed that the highest of seed yield was obtained from irrigation during full season (control) and the most reduction of seed yield was achieved from water deficit stress in budding stage (Table 3). Wright, (1995) compared compatibility of Brassica napus and Brassica juncea in water stress conditions. Results showed that both species decreased yield.

The interaction effect of irrigation and canola cultivars indicated that the most seed yield reduction from water deficit stress was in budding stage and for cv. Sarigol was 2858 kg ha^{-1} (Table 4). So, the overall performance of the cultivars for seed yield indicates that under water deficit stress, the cv. RGS003 is superior to other cultivar. Hence, it can withstand low levels of water regimes. Results obtained from the water deficit effects on different stages of the canola growth have indicated that the most seed yield reduction was from water deficit stress treatment in budding stage and then in flowering stage while water deficit stress treatment in ripening stage reduced the seed yield less than before stages (Table 4).

Water consumption efficiency in various growth stages of the cultivars of the canola have been reported in Table 5. The highest water consumption efficiency was obtained for the cv. RGS003 and from water deficit stress treatment in ripening stage that was 0.682 ha^{-1}, while the least water consumption efficiency rate was 0.482 ha^{-1} for the cv. Sarigol and from water deficit stress in flowering stage.

Table 1. Mean squares and their significance from analysis of variance for various traits under Irrigation treatments in canola cultivars

Source of variation	df	Plant height	branches per plant	Siliqua per plant	Seed yield
Replication	3	50.86	0.49	349.86	292667.14
cultivar effects	1	32.58^{ns}	3.02^{*}	4758.94^{*}	2175103.2^{**}
Error A	3	11.64	0.09	283.11	37258.28
Irrigation treatments	4	258.34^{**}	0.46^{*}	3644.29^{**}	1693716.2^{**}
Cultivar x Irrigation	4	23.84^{*}	0.46^{ns}	1242.61^{**}	17497.51^{ns}
Error B	24	7.23	0.27	110.32	24311087
CV (%)	-	1.99	12.03	4.89	4.37

Comparison among mean values significant at non significant (ns), *P <0.05 and **P < 0.01

Table 2. Mean comparison of effects on various traits in canola cultivars

cultivar	Plant height	branches per plant	siliqua per plant	Seed yield
Sarigol	134.5 a	4.6 a	203.9 b	3336 b
RGS003	132.3 a	4.0 b	225.7 a	3803 a

Table 3. Mean comparison of effects for various treatments of irrigation on various traits in canola cultivars

Irrigation treatments	Plant height	branches per plant	siliqua per plant	Seed yield
irrigation during full season (control)	142.6 a	5.12 a	241.1 a	4252 a
water deficit stress in stemming stage	133.9 b	4.25 b	221.1 b	3504 c
water deficit stress in budding stage	130.4 c	3.37 c	189.2 c	3074 e
water deficit stress in flowering stage	130.1 c	3.87 bc	197.1 c	3260 d
water deficit stress in ripening stage	140.1 a	5.1 a	225.9 b	3757 b

Table 4. The interaction effects for various treatments of irrigation on various traits in canola cultivars

Irrigation treatments	cultivar	Plant height	branches per plant	siliqua per plant	Seed yield
irrigation during full season (control)	Sarigol	97	136	39	4070
	RGS003	93	131	38	4435
water deficit stress in stemming stage	Sarigol	97	136	39	3302
	RGS003	93	131	38	3706
water deficit stress in budding stage	Sarigol	97	136	39	2858
	RGS003	93	131	38	3290
water deficit stress in flowering stage	Sarigol	97	136	39	2980
	RGS003	93	131	38	3541
water deficit stress in ripening stage	Sarigol	97	136	39	3472
	RGS003	93	131	38	4042

Table 5. Water consumption efficiency in various treatments of irrigation in canola cultivars

Irrigation treatments	cultivar	volume of the consumed water	Seed yield	Water consumption efficiency
irrigation during full season (control)	Sarigol	6783	4070	0.626
	RGS003	6783	4435	0.653
water deficit stress in stemming stage	Sarigol	5926.4	3302	0.557
	RGS003	5926.4	3706	0.625
water deficit stress in budding stage	Sarigol	5926.4	2858	0.482
	RGS003	5926.4	3290	0.555
water deficit stress in flowering stage	Sarigol	5926.4	2980	0.502
	RGS003	5926.4	3541	0.597
water deficit stress in ripening stage	Sarigol	5926.4	3472	0.585
	RGS003	5926.4	4042	0.682

CONCLUSION

Ability of improving canola cultivars that able to maximum use of existing water and drought tolerant is the main objectives of increasing seed yield potential in semi-arid and dry areas. As it was shown in the results of this study, water deficit stress had a negative effect on most of the traits under study. During our investigation, the analysis of variance showed that canola varieties as the main plots had significant difference in number of branches per plant, number of siliqua per plant, seed yield but these results haven't shown significant effects in plant height. Irrigation treatments as the sub plots led to a significant difference for all of traits. The highest water consumption efficiency was obtained for the cv. RGS003 and from water deficit stress treatment in ripening stage that was 0.682 ha^{-1}, while the least water consumption efficiency rate was 0.482 ha^{-1} for the cv. Sarigol and from water deficit stress in flowering stage. The interaction effect of irrigation and canola cultivars indicated that the most seed yield reduction from water deficit stress was in budding stage and for cv. Sarigol was 2858 kg ha^{-1}. So, the overall performance of the cultivars for seed yield indicates that under water deficit stress, the cv. RGS003 is superior to other cultivar. Hence, it can withstand low levels of water regimes.

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