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Full Length Research Paper

Studying of oil yield variations in winter rapeseed (*Brassica napus* L.) cultivars under drought stress conditions

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This experiment was carried out using a split plot design with three replications to study the effect of drought stress on oil yield variations in winter rapeseed cultivars at Iran. The factors including irrigation regimes (control, irrigation interrupted from flowering stage, irrigation interrupted from silique formation stage and irrigation interrupted from seed filling stage) in main plots and cultivars (Zarfam, Okapi and Licord) in subplots were studied. Our data showed that rapeseed cultivars significantly affected oil yield, grain yield, thousand grain weight, silique number per plant and grain number per silique in $P \leq 0.01$, whereas drought stress had significant effect on thousand grain weight in $P < 0.05$ and grain number per silique in $P \leq 0.01$. The results of this experiment showed that the highest oil yield and thousand grain weight were achieved by Okapi cultivar under control irrigation, highest grain yield and silique number per plant were obtained by Licord cultivar under control irrigation and highest grain number per silique was achieved by Zarfam cultivar under control irrigation and high drought tolerance index was exhibited by Licord cultivar. Our findings indicated that drought stress reduced oil yield of rapeseed cultivars sorely.

Key words: Drought stress, oil yield, drought tolerance index, winter rapeseed cultivars.

INTRODUCTION

The agricultural use of water in the world is > 85% of total water use, moderate to severe intermittent or terminal drought is a common occurrence, and dry most crops cannot be grown without supplemental irrigation (Cook et al., 2004). Drought also limits adaptation of pulse crops in the world (Miller et al., 2002). Drought during emergence and vegetative growth stages reduces plant population and biomass yield. However, in general, dry canola is more sensitive to drought during pre-flowering (10–12 d before anthesis) and flowering stages causing excessive flower, young silique, and seed abortion (Lizana et al., 2006). Thus, the growth stages as affected by intensity and duration of drought determine the extent of losses in seed yield and quality. Drought affects water-use efficiency and plant and seed uptake and utilization of most major and minor nutrients (Munoz-Perea et al., 2007). Drought reduces biomass and seed yield, harvest index, number of silique and seeds, seed weight, and days to maturity (Abebe and Brick, 2003; Munoz-Perea et al., 2006; Padilla-Ramirez et al., 2005). Moreover, drought increases cooking time and seed protein content on dry weight basis (Frahm et al., 2004).

Drought tolerance consists of ability of crop to growth and production under water deficit conditions. A long term drought stress effects on plant metabolic reactions associates with, plant growth stage, water storage capacity of soil and physiological aspects of plant. Drought tolerance in crop plants is different from wild plants. In case crop plant encounters severe water deficit, it dies or seriously loses yield while in wild plants their surviving under this conditions but no yield loss, is taken into consideration. However, because of water deficit in most arid regions, crop plants resistance against drought, has always been of great importance and has taken into account as one of the breeding factors (Alizadeh, 2004). One of the main aspects of plant tolerance is ability of

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plant cells to survey under severe water content lose without suffering sharp damages. While cell dries, usually vacuole crumples more than cell wall so, results in tearing protoplasm. It seems that such damages are the main reasons for cell death which has no tolerance mechanism (Lessani and Mojthaedi, 2002).

Plant yield lose under insufficient water is an important issue for plant breeders and they tend to improve plant yield in this case but, difference in yield potential more relates to compatibility to stress factors So, drought tolerance indices are used to determine tolerant genotypes (Mitra, 2001). The objective of Biabani et al. (2008) was to investigate SPAD meter readings variations of rapeseed leaves under different treatments. A pot experiment was conducted at a controlled glasshouse at Iran. Treatments were various rapeseed cultivars (Hayola 401, Hayola 308, Option and RGS) and irrigation regimes (FC (without stress), 75% FC, 50% FC and 25% FC). The results showed that with increase in drought stress, SPAD meter readings (the relative chlorophyll concentration of leaves) were decreased. Results showed that, drought stress had a significant effect on net photosynthesis (A), stomata conductance (g_s) intercellular CO_2 concentration (C_i) and leaf area (LA) of rapeseed at both vegetative and flowering stages. In general, Hayola 401, had the highest yield in both control and drought treatments, followed by Hayola 308, whereas RGS had the lowest yield among the cultivars. Hayola 401 and Hayola 308, had the highest g_s in control and the lowest g_s in drought treatments. Cultivars tolerance rankings in this study, was Hayola 401, Hayola 308, Option and RGS. In a study investigated the effects of water stress on rapeseed. Yield and yield components were mainly affected by water shortage occurring from flowering to the end of seed set.

The greatest reduction (48%) was observed when only 37% of full water requirement was supplied to the plant during this stage. The number of seeds per plant was the main yield component affected. Some compensation occurred when the water supply was restored. The 1000-seed weight was only affected by a water stress from the stage when the siliques were swollen until the seeds colored stage. The experiment of Kargarzadeh et al. (2008) was carried out by split plots design with 4 replications. The factors which studied were drought stress that normal irrigation, irrigation interrupted from stem production stage and irrigation interrupted from flowering stage and Okapi, Licord, Talaye, S.L.M 046 and Zarfam cultivars. The results showed that upon treatments significant effects on biological yield, seed yield, harvest index, oil yield, oil percent, seed thousand weight, branches number, highest plant, skin number, skin length and seed number of skin. The results of this experiment showed that highest oil yield was achieved under normal irrigation and Okapi cultivar. Therefore, The objectives of this study were investigation of effects of drought stress on drought tolerance indices of rapeseed cultivars and evaluation of correlations between yield under stress and normal conditions and drought tolerance indices in order to selecting cultivars having high and stable yields under these conditions at Karaj region, Iran.

MATERIALS AND METHODS

This study was conducted on experimental field of Seed and Plant Improvement Institute, Karaj at Iran (35°58' N, 51°06' W; 1313 m above sea level). The experiment was carried out using by a split plot design with three replications. The factors including irrigation regimes (control, irrigation interrupted from flowering stage, irrigation interrupted from silique formation stage and irrigation interrupted from seed filling stage) in main plots and cultivars (Zarfam, Okapi and Licord) in subplots were studied. Initially, plant nutrient feed of phosphorus and potassium were added by applying 100 kg ha^{-1} triple super phosphate and 100 kg ha^{-1} K_2O after cultivation respectively. Nitrogen fertilizer was added in three periods; application of 50% N at cultivation time, application of 25% N fertilizer at stem elongation stage and application of 25% N fertilizer in beginning of flowering stage. To determine oil yield, grain yield, thousand grain weight, silique number per plant and grain number per silique, 10 plants were selected randomly from each plot at maturity and then, oil yield was determined by the Inframatic system. The drought tolerance index (DTI) was determined by following formula (Ober et al., 2004):

DTI = (Ypi)(Ysi)/$(Ypi)^2$.
Ypi = Cultivar grain yield in non-stress condition.
Ysi = Cultivar grain yield in stress condition.

The data were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) computer software at $P<0.05$ (SAS institute Cary, USA 1988).

RESULTS

The final results showed that rapeseed cultivars significantly affected oil yield, grain yield, thousand grain weight, silique number per plant and grain number per silique in $P \leq 0.01$, whereas drought stress had significant effect on thousand grain weight in $P < 0.05$ and grain number per silique in $P \leq 0.01$ (Table 1). The results of this experiment showed that the highest oil yield (2123.9 kg ha^{-1}) and thousand grain weight (5.06 g) were achieved by Okapi cultivar under control irrigation, highest grain yield (3882.4 kg ha^{-1}) and silique number per plant (186.4 silique/plant) were obtained by Licord cultivar under control irrigation and highest grain number per silique (23.1 grain/silique) was achieved by Zarfam cultivar under control irrigation (Table 2). Also, a positive correlation was between oil yield character and grain yield, thousand grain weight, silique number per plant and grain number per silique features (Table 3). The high drought tolerance index in irrigation interrupted from flowering stage (0.899), irrigation interrupted from siliqueing stage (0.971) and irrigation interrupted from seed formation (0.948) were exhibited by Licord cultivar (Table 4).

Table 1. Variance analysis of determined characteristics in winter rapeseed cultivars.

Value sources	df	Mean squares				
		Grain yield	Oilyield	Thousand seed weight	Silique number per plant	Grain number per silique
Replication		1783841.182	627123.126	0.514 *	3151.75	28.784 **
Drought stress		7523713.148	2484970.115	2.723 *	4542.704	124.653 **
Error a		3186811.734	767537.921	0.127	5421.719	3.763
Cultivars		1120364.219 **	286112.324 **	0.854 **	7031.657 **	70.177 **
Drought stress × cultivars		232615.199	6374.456	0.134	238.6	12.716 **
Error b		446458.364	87284.124	0.124	1025.763	6.237
CV (%)		18.48	18.68	8.43	19.38	10.28

*and **: Significant at 5 and 1% levels, respectively.

Table 2. Means comparison of interaction between irrigation regimes and winter rapeseed cultivars

Survey instance qualification		Grain yield (kg/ha)	Oil yield (kg/ha)	Thousand seed weight (g)	Silique number per plant (silique/plant)	Grain number per silique (grain/silique)
Control	Licord	4549.2 a	1535.9 abcd	4.86 ab	186.4 a	22.5 abc
	Okapi	3882.4 abc	2123.9 a	5.06 a	94.6 abc	22.9 ab
	Zarfam	3294.4 abcd	1609.2 abc	5.02 a	183.9 a	23.1 a
Irrigation interrupted from flowering stage	Licord	3012.6 bcd	1515.5 abc	4.73 abc	87.6 abc	21.1 ab
	Okapi	2683.2 cde	1719.1 ab	4.56 abc	89.3 abc	19.9 abc
	Zarfam	3212.5 abc	1586.4 bc	4.98 ab	127.4 ab	18.6 bcd
Irrigation interrupted from silique formation stage	Licord	3256.2 bcd	1527.7 bcd	4.63 bcd	83.1 bcd	23.4 ab
	Okapi	3005.3 cde	1929.9 abc	4.53 bcd	89.1 ab	21.3 abc
	Zarfam	3413.2 abc	1599.9 ef	4.89 abc	152.4 ab	19.2 bcd
Irrigation interrupted from seed filling stage	Licord	3177.3 bcd	1457.6 bcd	4.36 bcd	82.7 abc	21.8 ab
	Okapi	2975.4 cde	1688.9 ab	4.27 bcd	88.9 ab	21.1 abc
	Zarfam	3322.1 abc	1421.4 de	4.63 abc	150.2 ab	18.9 bcd

Means within the same column and factors, followed by the same letter are not significantly difference.

DISCUSSION

As it was shown in the results of this study, drought stress had a negative effect on most of the morphological features under study, this shows that in order to resist drought stress, the plant uses different ways. Great reduction in the length and width of the leaf and accordingly reduction in the leaf area, reduction in the plant

Table 3. Correlation analysis of determined characteristics in winter rapeseed cultivars.

Characteristic	Grain yield	Oil yield	Thousand seed weight	Silique number per plant	Grain number per silique
Grain yield	1				
Oil yield	0.987 **	1			
Thousand seed weight	0.635 **	0.679 **	1		
Silique number per plant	0.582 **	0.527 *	0.149	1	
Grain number per silique	0.718 **	0.683 **	0.276	0.607 **	1

*and **: Correlation at 5 and 1% levels, respectively.

Table 4. Drought tolerance index of winter rapeseed cultivars.

Irrigation interrupted from flowering stage (SI = 0.756)			
Cultivars	Licord	Okapi	Zarfam
Drought tolerance index	0.899	0.676	0.687
Irrigation interrupted from silique formation stage (SI = 0.821)			
Cultivars	Licord	Okapi	Zarfam
Drought tolerance index	0.971	0.757	0.730
Irrigation interrupted from seed filling stage (SI = 0.804)			
Cultivars	Licord	Okapi	Zarfam
Drought tolerance index	0.948	0.750	0.710

height and tiller number, all contribute to the reduction of plant’s evaporation area and consequently reduction in the produced dry matter is the final result of the reduction in the plant’s photosynthesis which in turn, is the result of drought stress. Under drought stress, stomata’s become blocked or half-blocked and this leads to a decrease in absorbing Co_2 and on the other hand, the plants consume a lot of energy to absorb water, these cause a reduction in producing photosynthetic matters. Drought stress reduced the amount of the oil, because in case of stress, more metabolites are produced in the plants and substances prevent from oxidization in the cells. It was also seen that as the increase of drought stress, its height plant, stem diameter and stem yield decreased. Shoot reduction could be due to the reduction in the area of photosynthesis, drop in producing chlorophyll, the rise of the energy consumed by the plant in order to take in water and to increase the density of the protoplasm and to change respiratory paths and the activation of the path of phosphate pentose, or the reduction of the root deploy, etc. The oil yield decreased of rapeseed cultivars, the interaction between the amount of the oil and grain yield is considered important as two components of the oil yield. As it can be seen in Table 2, by exerting stress, the amount of the oil was dropped.

Our results were similar to the findings of Biabani et al. (2008); Singh (2007) and Aliabadi et al. (2009).

Conclusion

The investigation showed that oil yield was decreased under drought stress. This condition can be the most important environmental factor for the increase of oil yield by control of irrigation. Therefore, the selection of cultivars that perform well over a wide range of environments can increase quantity and quality yields of rapeseed under drought stress. Consequently, our findings may give applicable advice to farmers and agricultural researchers for management and proper use of irrigation in farming of rapeseed under drought regions.

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