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Investigation of humidity regimes effect on morphophysiological traits of new rapeseed cultivars

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ABSTRACT: Present study investigated the effect of drought stress on new rapeseed cultivars to select the most tolerant cultivars for dry regions in Iran . cultivars contained L73, L72, L146, L210, L183, L201 under conditions designed as; normal irrigation, stopping the irrigation from step elongation stage, flowering stage and podding stage. Mean comparison analysis showed that the L210 in normal irrigation had the highest yield of seed with 5899 kg/ha the highest yield of seed oil production as well as the highest harvest index counts (29.99%) .On the other hand, removal of irrigation at stem elongation stage resulted in dramatic reduction of grain yield for the L183 with 1388 kg/ha. Moreover, the L183 had the lowest oil yield production (573 kg/ha) and showed the lowest harvest index (17.07%). Furthermore, the L183 showed the highest content of erucic acid (0.1997%) whereas, the L210 showed the lowest content of erucic acid (0.135%). In conclusion, among the studied cultivators the L210 selected as the best cultivar for the normal condition and the L73 is the best cultivars in stress was started from stem elongation stage and stress was started from flowering stage, also, the cultivar L183 is the best cultivars in stage of stress was started from pod formation.
Key words: rapeseed, drought stress, seed yield, oil yield, content of erucic acid.

INTRODUCTION

Canola (*Brassica napus* L.) is one of the most important oil crops both in Iran and throughout the world. Oilseed canola plant is an agriculture crop grown primarily for its edible oil and the meal that remains after oil extraction has value a source of protein for the livestock feed industry (Jensen et al., 1996).The water deficiency can influence inversely the grain of canola but this effect depends on the genotype, growth stage and the plant adaption to the drought (Azizi et al., 1999). Among the different abiotic stresses like heat, salinity and freezing drought stress is a more sever constraint that limits growth and productivity of crop plants(Yamaguchi-Shinozaki *et al.,* 2002). Even temporary drought can cause substantial losses in crop yield. The greatest challenge for coming decades will be the task of increasing food production with less water, particularly in countries with limited water and land resources (Abbasian et al., 2012). Water stress affects both vegetative and reproductive stages in canola (Faizan et al., 2012). Drought resistance is a complex trait, expression of which depends on action and interaction of different morphological (earliness, reduced leaf area, leaf rolling, wax content, efficient rooting system, awn, stability in yield and reduced tillering), physiological (reduced transpiration, high water-use efficiency, stomatal closure and osmotic adjustment) and biochemical (accumulation of proline, polyamine, trehalose, etc., increased nitrate reductase activity and increased storage of carbohydrate) characters (Mitra, 2001). The objective of this study was investigation some agro morphological and physiologic characteristics of winter canola genotypesin response to water stress and identifying drought tolerance canola genotypes. So that suitable genotypes can be recommended for cultivation in drought prone areas of Iran.

MATERIALS AND METHODS

This study was carried out at the experimental farm of seed and plant improvement institute, Karaj, Iran (latitude 35° 59' N, longitude 50° 75' E, altitude 1313m above mean sea level) in 2012-2013. The climate was characterized by mean annual precipitation of 224 mm. the soil has loam clay texture with 0.64 organic matter and some of physical and chemical properties are shown in table 1.The experimental design was split plot on basis of randomized complete block design (RCBD) with tree replications. Four irrigation levels consist of irrigation after 80 mm evaporation from class “A” pan as control, stopping the irrigation from step elongation stage, flowering stage, podding stage were applied in main plot and sub plot which consisted of split plot were devoted of six cultivars (L 201, L183, L146, L210, L72,L 73). This experiment contain 72 plot that individual plot consist of 6 rows, 5 m long and spaced 30 cm apart. The experimental fields were mould-board ploughed and seedbed preparation consisted of two passes with a tandem disk. Seeds were planted by hand 1 to 1.5 cm deep. For all treatments N: P: K fertilizers applied. P, K and one- third of N were applied per plant and incorporated. Other two-third of N was split equally at the beginning of stem elongation and flowering. Weeds were controlled by application of trifluralin at 2.5 L ha^{-1}.*Brevicoryne brassicae* was controlled by using of Metasystox _ R (Oxydemeton _ methyl) at 1.5 $L.ha^{-1}$ and ekatin (**thiomton**) at 1 $L.ha^{-1}$The following measurements were carried out: pod length, branch numbers per plant, number of pods per plant (with at least on seed), number of seed per main and secondary pod, 1000 seed weight, seed yield and harvest index. Seed oil was determined by Nuclear Magnetic Resonance (NMR). Glucosinolate, acid Erucic and acid oleic content were determined by HPLC. For measuring of traits 10 plants selected randomly from each plot.

Table 1. result of some chemical and physical analysis of experimental soil

Depth	Potassium (mg per kg soil)	Phosphorus (mg per kg soil)	N %	Clay %	Silt %	Sand %	EC (DS/m)	pH
0-30	275	103	0.06	41.88	29.32	28.80	1.70	7.74

Statistical Analysis

The experimental data were statistically analyzed for variance using the MSTATC. When analysis of variance showed significant treatments effects, Duncan Multiple Range Test was applied to compare the means at $P<0.05$.

RESULT AND DISCUSSION

The analysis of variance showed significant difference between treatments (different water deficient levels and genotypes). Also interaction effect of irrigation × genotype for all traits was significant (table 2). The result indicated that the levels of water stress had different influence and genotype had distinctive responses. Mean comparison show that genotype L210 in control condition has highest mean for all trait exception erucic acid and glocosinolate and genotype L183 in stopping the irrigation from stem elongation stage has lowest mean for all trait but erucic acid and glocosinolate was highest content in L183. Also L73 had highest content for all traits instopping the irrigation from stem elongation stage exception glocosinolate that was lowest.In the present study, the reduction in seed yield under water stress was associated with dramatic decrease in all these yield components (Table 3). Supporting evidences were reported by many researchers (Turk and Hall, 1980; Ziska and Hall, 1983; Ludlow and Mushow, 1990; Gwathmey and hall, 1992). They attributed the reduction in seed yield under water stress to the reduction in number of pods per plant, number of seeds per pod and seed weight. Similarly, Ravindra *et al*. (1990) attributed the loss in seed yield to low fruiting efficiency and lack of filling time for pods.

Table 2. Analysis of variance for yield and yield components of rapeseed cultivars. Irrigation (I), Variety (V), interaction Irrigation and Variety (I×V)

	MS												
SOV	Df	Pod length	Number of seeds per main pod	Number of seeds per secondary pod	Number of pods in plant	Branch numbers per plant	1000 seed weight	Seed yield	Harvest index (%)	Oil content (%)	Ericic acid (%)	Olenic acid (%)	Glocosinolate mg/ dw
I	3	**77.36	**472.1	**461.11	**38329.85	**83.23	**16.53	**32021800.45	*95.82	**53.19	**142.17	**21.75	**230.3
V	5	*0.53	^{ns} 3.52	^{ns} 2.40	**253.61	^{ns} 0.26	^{ns} 0.25	*457569.42	^{ns} 11.94	**0.26	^{ns}0.27	^{ns}0.07	^{ns}0.95
(I×V)	15	**0.59	*8.60	*2.92	**210.62	*0.92	*0.46	**504240.55	*31.89	*0.17	**0.5	*0.43	*3.32
CV		8.51	8.38	9.97	15.63	7.85	15.64	11.78	16.87	2.63	2.29	3.64	4.69

ns, *, **: no significant, significant at the 5 % and 1 % levels of probability, respectively.

Pod length

results show that largest pod length was 8.2 cm in L210 in control condition shortest pod length was 2.5 cm in L183 in stopping the irrigation from stem elongation stage. Pods contain seed and in primary stage of filling seed interferein seed growth by photosynthesis. Big pod supply big source for photosynthesis material so lead to increasing yield. Unsuitable condition decrease transfer of nutrition to seeds, then decrease yield.(Rad et al., 2010) Moisture stress cause reduction in leaf chlorophyll content of plants (Sun *et al*., 2011). Therefore, for better yields under stress, higher chlorophyll content might contribute to higher plant productivity (Rao *et al*., 2012).

Branch number per plant

the interaction irrigation ×variety was significant on branch number per plant ($p= 0.01$). Lowest and highest branch number per plant was for L183 in in stopping the irrigation from stem elongation stage (3.2) and L210 in control condition (8.7) respectively. Canola branching capacity is considerable if plant has enough space. The desired number of branches in the unit of surface is closely related to the soil moisture regime during the plant growth period (Ardell et al., 2001). Reduced number of branches during the shortage of soil moisture has been reported earlier (Naeemi et al., 2007).

Number of pod in plant

Mean comparison showed highest Number of pod in plant (164.6) in L210 in control condition and the lowest Number of pod in plant in L183 (41.07) in stopping the irrigation from stem elongation stage. Mendham and Salisbury (1995) reported that supply water in beginning of pod growth is very important and they observed water stress affect pod growth in primary stage while water stress after this stage affect number of seed per pod. The significant reduction in number of harvested pods per plant under water stress may be attributed to the abscission of the reproductive structures. Ziska and Hall (1983) and Gwathmey and Hall (1992) reported similar results.

Number of seeds per main and secondary pod

The lowest and highest amount of number of seed per main pod was in L183 in stopping the irrigation from stem elongation stage (12.9) and L210 in control condition (28.6) respectively. Amount of number of seed per secondary pod was lowest an highest in L183 (9.5) and L210 (24.1), respectively. Water disruption during flowering and grain filling stages may increase flower and pod abortion, thus decreasing the seed number per plant. Similar results were reported for chickpea (Ghasemi Golezani, et al. 2008), soybean (Demitras, et al. 2010) . It has been found that the ability of different rapeseed genotypes to form seeds is different and the number of seeds is affected by genetic factors (Rao and Mendham, 1991).

Mendham and Salisbury (1995) reported that competition for assimilates among new branches and extra pod formation the time when seed numbers are set was responsible decreasing in seeds per pod as well. Abiotic stress at the later stages of reproductive growth can result in source limitation for seed yield by inducing leaves shedding and hastening maturity (Gan et al., 2004).

1000 seed weigh

The lowest and highest 1000 seed weigh was in L183 in stopping the irrigation from stem elongation stage (2.1 gr) and L210 in control condition (5.1 gr) respectively.Pazouki (2000) showed that shortening interval irrigation increases 1000-seed weight, also It is observed that with increasing water to 80 % evaporation from class “A” pan, 1000-seed weight achieves to uttermost and with increasing period of irrigation, 1000-seed weight decreases significantly In water stress conditions leaf expansion rate decreases (Kumar et al., 1993), stomata close and photosynthesis rate reduces leading to the production of smaller seed resulting in reduced 1000 seed weight (Monddal and khajuria, 2000).

Seed yield

seed yield was highest (5899 $kgha^{-1}$) in L210 in control condition and lowest in L183 (1388 $kg\ ha^{-1}$) in stopping the irrigation from stem elongation stage. In fact under non water-stressed conditions L210 genotypes significantly gave better seed yields than under water-stressed conditions and the genotype L73 comparatively was the highest seed-yielding genotype under both conditions (Table 3).Stresses imposed at a later stage of development reduce sink size, shorten the duration of seed filling and decrease the opportunity of crop to recover. Irrigation had more influence on seeds per pod than other yield components and water deficit influenced flowering to maturity stages more than other growth stages (Ahmadi and Bahrami, 2009). Daneshmand *et al*., (2007) suggested that at water stressed conditions, those rapeseed cultivars which were able to maintain their relative water content at high levels had higher seed yield.Since water stress during seed development did affect on the sink size (seeds per plant), decreased source capacity led to reduction of seed weight. Champolivier and Merrien (1996) reported that the most sensitive period of *B.napus* to water stress was between flowering and pod development.

Oil content

mean comparison shows that highest and lowest oil content was in L210 (45.48) in control condition and L183 (41.24) in stopping irrigation from stem elongation stage, respectively.Previous studies showed that drought stress significantly decreased the seed oil content of canola. In our study, the observed variations in oil contents of seeds were apparently more dependent on environmental factors such as water availability than on genotypic traits and reduction of oil content was at stem elongation.

Table 3. Mean comparison for pod length (PL), number of seeds per main pod (G/MP), number of seeds per secondary pod (G/SP), number of pods per plant(P/Pl), branch number per plant (BNP), 1000 seed weight (1000 SW), seed (SY) yields, harvest index(HI), oil content(OC), Ericic acid (%), Olenic acid (%) and Glocosinolate mg/ DW. Control (I1), stopping the irrigation from stem elongation stage (I2), stopping the irrigation from flowering stage (I3) and stopping the irrigation from podding stage (I4).

treatment	PL(cm)	G/MP	G/SP	P/Pl	BNP	1000 SW (gr)	SY (Kg/ha^{-1})	HI (%)	OC (%)	Ericic acid (%)	Olenic acid (%)	Glocosinolate mg/ dw
I × V												
$I_1.V_1$	7.5 abc	26.7 a-b	22.8 abc	152/6 bcd	8.2 abc	4.6 abc	5153 bc	28.03 ab	45.15 ab	0.1412hij	63.92 bc	21.14 l
$I_1.V_2$	8 ab	28.1 ab	23.7 a	160/4 ab	8.6 ab	4.1 b-e	5405 ab	28.37ab	45.37 a	0.1348 jk	64.55 ab	20.16 l
$I_1.V_3$	6.9 cd	25.3 a-e	22.2 a-d	143/9 def	7.8 b-e	4.4 a-d	4526 cde	25.21 abc	45.05 ab	0.1475 gh	63.9 bc	22.12 jkl
$I_1.V_4$	8.2 a	28.6 a	24.1 a	164/6 a	8.7 a	5.1 a	5899 a	29.99 a	45.48 a	0/1315 k	64.7 5 a	20.11 l
$I_1.V_5$	7.8 ab	27.4 abc	23.1 ab	157/6 abc	8.4 ab	4.7 ab	5345 ab	28.71 ab	45.26 ab	0.1377 ijk	64.12 ab	20.25 l
$I_1.V_6$	7.3 bc	25.9 a-e	22.7 abc	147/2 cde	8.1 a-d	4.5 a-d	4997 bcd	27.93 ab	45.12 ab	0.1436 hi	63.9 1 bc	21.62 kl
$I_2.V_1$	3.3m-p	17.2 klm	13.2 jk	59/5 m	3.7 j	2.6 i-m	2541 h-k	25.99 ab	41.79 ijk	0.1979 ab	61.95 i-m	28.72 a-d
$I_2.V_2$	2.9 op	14.6 mno	11.2 klm	46/6 no	3.4 j	2.3 klm	2106 jk	23.44 abc	41.35 kl	0.1988 ab	61.52 lm	29.76 a
$I_2.V_3$	2.7 p	13.7 no	10.4 lm	43/8 no	3.3 j	2.2 lm	1796 kl	20.69 bc	41.29 kl	0.1992 a	61.68 lm	29.82 a
$I_2.V_4$	3 nop	15.3 mno	11.7 kl	49/8 mno	3.5 j	2.4 klm	2134 jk	23.28 abc	41.48 kl	0.1986 ab	61.65 klm	29.12 ab
$I_2.V_5$	2.5 p	12.9 o	9.5 m	41/7 o	3.2 j	2.1 m	1388 l	17.07 c	41.24 l	0.1997 a	61.29 m	29.91 a
$I_2.V_6$	3.1 nop	16.5 lmn	12.1 kl	53/8 mn	3.6 j	2.5 j-m	2337 ijk	24.84 abc	41.64 jkl	0.1982 ab	61.74 j-m	28.86 abc
$I_3.V_1$	4.6 hij	21.7 f-j	17.1ghi	105 i	5.4 h	3.3 e-k	3293 gh	25.78 ab	42.93 f	0.1876 c	62.71 d-h	26.13 e-h
$I_3.V_2$	3.7 k-n	19.5 i-l	15.5 i	83/1 kl	4.7 hi	2.8 g-m	2852 g-j	24.77 abc	42.25 ghi	0.1935 abc	62.22 g-l	27.12 b-e
$I_3.V_3$	4.2 i-l	20.4 h-k	16.2 i	94/7 ij	5.1 hi	3.1 e-m	2924 ghi	25.04 abc	42.42 gh	0.1907 c	62.44 f-j	26.55 def
$I_3.V_4$	3.6 l-o	19.1 jkl	15.1 ij	77/8 l	4.5 i	2.7 h-m	2827 g-j	25.35 abc	42.06 hij	0.1948 abc	62.16 h-l	27.27 b-e
$I_3.V_5$	4.4 h-k	20.9 g-j	16.7 hi	102/4 i	5.2 hi	3.2 e-l	3081 ghi	24.99 abc	42.68 fg	0.1889 c	62.52 e-i	26.44 efg
$I_3.V_6$	4 jom	20.1 h-k	15.7 i	88/8 jk	4.8 hi	2.9 f-m	2918 ghi	24.87 abc	42.33 gh	0.1917 bc	62.62 j-k	26.72 c-f
$I_4.V_1$	6 ef	24.3 c-g	20.7 c-f	139/2 efg	7.3 d-g	3.9 b-f	4122 ef	26.26 ab	44.57 cd	0.1546 ef	63.23 cde	24.11 hij
$I_4.V_2$	4.9 ghi	22.8 e-i	18.5 fgh	119/7 h	6.5 g	3.5 d-j	3129 gh	23.3 abc	44.02 e	0.1618 d	62.9 d-h	25.41 e-i
$I_4.V_3$	5.7 efg	23.9 d-g	20.2 def	134/4 fg	7.2 efg	3.8 b-g	3545 fg	23.39 abc	44.29 de	0.1552 def	63.15 def	24.28 ghi
$I_4.V_4$	5.2 gh	23.2 e-h	19.1 efg	122/9 h	6.7 fg	3.6 c-i	3217 gh	22.97 abc	44.05 e	0.1609 de	62.96 d-g	25.12 e-i
$I_4.V_5$	6.4 de	24.9 b-f	21.1 b-e	140/5 ef	7.5 c-f	4.1 b-e	4318 de	26.38 ab	44.78 bc	0.1512 fg	63.35 cd	23.62 ijk
I4.V6	5.5 fg	23.5 d-h	19.6 ef	129/4 gh	6.8 fg	3.7 b-h	3306 gh	22.63 abc	44.17 de	0.1587 de	63.11 def	24.77 f-i

Mean followed by the same letter(s) in each column are not significantly different (Duncan 5%)

Harvest index

wright et al. (1995) obtained reduction of harvest index. 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.

Fatty acid

fatty acid composition of storage triglycerides is subject to both environmental and endogenous controls. According to Mingeau (1974), water shotage during the rate flowering period could include a delay in lipid biosynthesis in rapeseeds involving oleic acid accumulation at the expense of the linolenic and erucic acid content. Fatty acids contain erucic acid and glocosinolate had highest and lowest content in L183 in stopping the irrigation from stem elongation and L210 in control condition respectively. oleic acidwas highest L210 in control condition and lowest in L183 in stopping the irrigation from stem elongation.Pham-Thi et al., (1985) reported that water deficiency decreased the degree of fatty acids unsaturation which was attributed to the inhibition in the biosynthesis of polyunsaturated fatty acids and suppression in the activities of desaturases. Glocosinolates are sulpher containing compounds which impart pungent smell to oil of mustard and rape. The accumulation of glocosinolates under drought stress imposed during flowering has been reported earlier by Bouchereau et al., (1996) in rapeseed.

CONCLUSION

among the studied cultivators the L210 selected as the best cultivar for the normal condition and the L73 is the best cultivars in stress was started from stem elongation stage and stress was started from flowering stage, also, the cultivar L183 is the best cultivars in stage of stress was started from pod formation.

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