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REGULAR ARTICLE

Response of Canola advanced lines to delay plantings upon late season drought stress

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Abstract

In order to evaluation of canola advanced lines response to delay plantings under late season drought stress conditions, an experiment was carried out in a factorial split-plot arrangement based on RCBD with three replications during two years (2012-2014) in Karaj of Iran. Treatments were; (1): Planting date in two levels (16 October and 1 November), (2): irrigation, in two levels (I1: normal irrigation as control and I2: restricted irrigation after pod formation stage) as main plots and (3): twelve oilseed rape genotypes as sub plots such as BAL2, BAL1, BAL3, BAL6, BAL8, BAL9, BAL11, BAL15, L72, R15, L109 and Okapi. The interaction effects of planting date, irrigation and genotype on pod number per plant, seed number per pod, 1000-seed weight, seed yield, and oil yield were significant at 1% level probability. The maximum seed yield under planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation after pod formation stage) was observed in Okapi and L109, respectively). Among genotypes, R15 line under delay planting (1 November) and both normal irrigation and drought stress conditions (restricted irrigation after pod formation stage) showed the maximum seed yield.

Key words: Delay planting; drought stress; oilseed rape; oil yield; seed yield

Introduction

There are different types of climates in different regions of Iran, where approximately 85% of the land is situated in arid, semi-arid or hyper arid regions. There are reports showing the decrease in rainfall in different areas of Iran in recent decades (Modarres and da Silva, 2007).

Among the oilseed crops, *Brassica* species are most affected by drought, as these crops are mainly grown in arid and semiarid areas. Oilseed rape production significantly reduced due to water deficit stress. This yield reduction can be lessened by multiple approaches of plant management practices including breeding strategies (Zhan et al., 2014).

The breeding for stress tolerance is the real need of the day to develop excellent varieties for cultivation and increasing production

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(Zhan et al., 2014).

Canola is relatively poorly adapted to drought prone conditions (Wright et al., 1997) and its yield is often decreased if moisture stress occurred, particularly at reproductive stage (Ahmadi and Bahrani, 2009; Shirani Rad and Abbasian, 2011). The reduction in seed yield ranged from 19 – 39% compared with well-watered control, when drought stress was imposed at reproductive stage (Gunasekara et al., 2006). Even temporary drought stress caused substantial losses in brassica by affecting growth and yield traits (Pervez et al., 2009). However, genetic variations among genotypes to tolerate drought stress have been reported in wide variety of crops including canola (Kauser et al., 2006). Ul-Haq et al. (2014) reported that three genotypes of *Brassica napus* showed different response to irrigation treatments for plant height, number of branches, biological yield, number of pod, number of seeds per pod and seed yield. Higher seed yield under drought stress conditions resulted from various morphological and metabolic activities, in tolerant oilseed rape genotypes (Jabbari et al., 2016). Accordingly, the role of root morphology in improving drought tolerance is critical. In addition, having effective root system, maintaining SC and higher pod number are among the most important traits for oilseed rape yield maintenance, especially under drought stress conditions (Jabbari et al., 2016). Mirshekari et al. (2012) indicated that minimum seed yield of safflower was obtained from cutting irrigation in the last sowing date at heads forming, flowering and seed filling stages, respectively. Shirani Rad et al. (2014, 2015) reported that season of planting was significantly influenced all measured traits of rapeseed. Recently, Nasiri et al. (2017) reported the effect of plant density on yield and physiological characteristics of six canola cultivars. Given that, field studies were conducted using an agronomical practice including irrigation treatments and oilseed rape genotypes. The primary objective of this research is to study of drought tolerance in canola genotypes under late season drought stress conditions, grown in semi-arid regions.

Materials and methods

The experiments were conducted during the 2012-2014 growing seasons in the Seed and Plant Improvement Institute, Karaj, Iran (35° 50′ 08′′ N, 51° 00′ 37′′ E). The Karaj region is characterized as cold semi-arid steppe climates (BSk by the Köppen-Geiger classification system) with relatively warm summers and cold winters. The average annual temperature is 14.2 °C and the average annual rainfall is 244 mm in Karaj. Before planting, several soil samples were collected and tested for physico-chemical properties.

Land preparation and introduction of treatments

Oilseed rape was planted following wheat in karaj. The field was prepared by shallow plowing, followed by disking in September and October. Each experimental unit was 4 m long and consisted of 4 rows spaced 0.3 m apart. The main plot treatments were irrigation, which was defined included (1): Planting date in two levels such as 16 October and 1 November, (2): irrigation, in two regimes (I_1: normal irrigation as control and I_2: restricted irrigation after pod formation stage) as main plots and (3): twelve canola genotypes as sub plots such as BAL2, BAL1, BAL3, BAL6, BAL8, BAL9, BAL11, BAL15, L72, R15, L109 and Okapi.

Standard recommended fertilizers and cultivation practices were followed in the experiment. To determine morphological and agronomical traits (including pod number per plant, seed number per pod, 1000 seed weight) 7 plants from each plot and to measure seed yield, 4.8 $m^2$of each plot was hand-harvested at the physiological maturity stage. The oil yield was estimated via multiplying seed oil percentage by seed yield.

Statistical analysis

All data were subjected to an analysis of variance (ANOVA) using the SAS software (SAS Institute, 2003).

Results and discussion

The results demonstrated that the interaction effects of planting date×irrigation×genotype on pod number per plant (PNP), seed number per pod (SNP), 1000-seed weight (SW), seed yield (SY), seed oil yield (OY) were significant at 1% level probability.

Pod number per plant (PNP)

The comparison means of Planting date×irrigation×variety showed that the maximum pod number (PNP) under Planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation from pod formation) related to R15 and L109 (167 and 153, respectively). In addition, the maximum pod number (PNP) under delay planting (1 November), normal irrigation and drought stress conditions (restricted irrigation from pod formation) related to R15, (135 and 121, respectively). The reduction in pod number under drought stress conditions is mainly due to an increase in pod abortion and shattering which is possibly a consequence of reduced photosynthate supply. It has been reported that the reduction in pod number under stress conditions is related to flower and pod abortion rather than reduction in flower production (Faraji et al., 2009).

Seed number per pod (SNP)

The comparison means of planting date×irrigation×genotype effect showed that L109 had the maximum seed number in pod (SNP) under planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation from pod formation) (Table 1). In contrast, R15 showed the highest seed number in pod (SNP), as 24 and 23, respectively, in delay planting (1 November), normal irrigation and drought stress conditions (restricted irrigation from pod formation) (Table 1).

Interaction of cultivar × irrigation has been shown significant for number of seeds per pod by Darjani et al. (2013). Similarly, the number of seeds in each pod was affected by stress in early stages of pod filling (Din et al., 2011).

In general, supplying enough water at the flowering and pod-setting stages increases the number of seed per pod. In *Brassicaceae*, number of seeds per plant is related to number of pod per plant and number of seed per pod, therefore drought stress at this stage reduced the seed number per plant (Wright et al., 1995). Shahsavari et al. (2014) reported that water stress decreases the number of pod in canola, and also that water stress, at the flowering stage, significantly decreases the number of pod in each plant, while postponed stress leads to a decrease in the number of seeds per pod.

Thomas et al. (2004) reported that the number of pod is more sensitive to water stress than other yield components. Moreover, Sinaki et al. (2007) pointed out that complete irrigation at first, at the pod-setting stage, had an important role in final yield, and that water stress, at this stage, decreased the length of pod and seed yield.

1000-seed weight (SW)

The comparison means of planting date×irrigation×genotype effect showed that the maximum 1000-seed weight (4.99 g) was achieved from R15 in Planting at the appropriate time (16 October), and drought stress irrigation (restricted irrigation from pod formation stage) treatment (Table 1). The interaction effect of planting date, irrigation and cultivar on SW showed that the maximum SW under planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation from pod formation stage) was observed in R15 and L109 as 4.99 g and 4.93 g, respectively (Table 1). Also, in delay planting (1 November), normal irrigation and drought stress conditions (restricted irrigation from pod formation) the maximum SW was observed in R15, 4.75 g and 4.15 g, respectively (Table 1). In other words, reduction of seed weight in delay planting and late season drought stress conditions (restricted irrigation from pod formation stage) is more likely due to increased leaf senescence, reduced leaf area duration and disruption in assimilate transfer into the seeds. The current results mirror those reported by Bitarafan and Shirani Rad (2012) who studied seed weight changes in response to restricted irrigation in oilseed rape.

Seed yield (SY)

In this study, the comparison means of planting date×irrigation×genotype effect showed that maximum seed yield (SY) under Planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation from pod formation) was observed in Okapi and L109 (5062 kg ha^{-1} and 3426 kg ha^{-1}, respectively). Among genotypes, R15 line under delay planting (16 October) and both normal irrigation and drought stress conditions (restricted irrigation from pod formation) showed the maximum SY (2818 kg ha^{-1} and 1986 kg ha^{-1}, respectively) (Table 2).

In this study, although R15 and L109 were relatively late maturing genotypes, was able to escape from drought periods by completing its life cycle before the harshest conditions and was obtained the maximum SY. In addition, higher SY under delay planting (1 November) in R15 was driven by more pod number, seed number and weight (Table 1). It should be kept in mind that in indeterminate plants like oilseed rape, there is a competition between vegetative and reproductive organs for produced assimilates, and drought stress whether during flowering stage or pod formation stage would affect photosynthates allocation between vegetative and reproductive organs (Sinaki et al., 2007).

Table 1. Mean comparison of some studied traits (2012-2014).

Planting Date	Irrigation	Genotypes	Mean					
			PNP		SNP		SW (g)	
16 October (Control)	Control	BAL1	d	152	b	26	d	4.8
		BAL2	fc	139	jk	24	j	4.6
		BAL3	e	145	ef	25	fg	4.7
		BAL6	kl	130	n	23	l	4.5
		BAL8	d	151	gh	25	gh	4.7
		BAL9	hi	135	kl	24	kl	4.5
		BAL11	fgh	137	fg	25	hi	4.7
		BAL15	klm	129	m	23	kl	4.5
		L72	d	150	bc	26	e	4.8
		R15	a	167	a	27	c	4.9
		L109	b	163	a	27	a	4.0
		Okapi	c	159	de	25	ef	4.8
	Restricted irrigation from pod formation stage	BAL1	f	140	kl	24	j	4.6
		BAL2	klm	129	q	22	m	4.4
		BAL3	ij	133	op	23	kl	4.6
		BAL6	p	121	v	21	r	5.3
		BAL8	hi	136	op	23	kl	4.5
		BAL9	op	123	tu	21	q	4.3
		BAL11	lmn	127	rst	22	m	4.4
		BAL15	stu	114	u	21	pq	4.4
		L72	gh	136	o	23	k	4.6
		R15	d	150	hi	25	ij	4.9
		L109	d	153	cd	26	b	4.9
		Okapi	no	125	st	22	no	4.4
Planting Date	irrigation	Genotypes	Mean					
			PNP		SNP		SW (g)	
1 November (Delay Planting)	Control	BAL1	kl	130	l	24	m	4.4
		BAL2	q-t	116	xy	20	u	4.0
		BAL3	qr	117	st	22	r	4.2
		BAL6	wx	105	vw	20	t	4.1
		BAL8	p	121	rs	22	s	4.2
		BAL9	q	118	rst	22	s	4.2
		BAL11	p	121	tu	21	s	4.2
		BAL15	w	107	wx	20	u	4.0
		L72	mn	127	pq	22	op	4.4
		R15	hi	135	ij	24	l	4.5
		L109	jk	131	lm	24	m	4.4
		Okapi	r-u	115	v	21	t	4.1
		BAL1	tu	113	r	22	u	4.0
		BAL2	x	103	z	19	w	3.8
		BAL3	y	98	z	19	v	3.9
		BAL6	z	88	z	18	w	3.8
		BAL8	x	104	z	19	x	3.8
		BAL9	uv	112	vw	20	v	3.9
		BAL11	w	107	yz	20	w	3.8
		BAL15	z	84	z	18	x	3.8
		L72	qrs	116	tu	21	u	4.0
		R15	p	121	mn	23	t	4.1
		L109	v	110	tu	21	v	3.9
		Okapi	v	110	xy	20	v	3.9

* PNP= Pod number per plant, SNP= Seed number per pod, SW= 1000 seed weight (g)
**Mean values of the same category followed by different letters are significant at $p \leq 0.05$ level.

Table 2. Mean comparison of some studied traits (2012-2014).

Planting Date	Irrigation	Genotypes	Mean			
			SY		OY	
16 October (Control)	Control	BAL1	cd	4213	d	1818
		BAL2	g	3691	fg	1574
		BAL3	e	3998	e	1727
		BAL6	i	3482	h	1485
		BAL8	c	4228	d	1808
		BAL9	g	3666	f	1586
		BAL11	f	3906	e	1703
		BAL15	h	3599	g	1548
		L72	d	4166	d	1815
		R15	b	4596	b	2024
		L109	b	4578	c	1956
		Okapi	a	5062	a	2193
	Restricted irrigation from pod formation stage	BAL1	l	3157	k	1294
		BAL2	m	2936	m	1196
		BAL3	n	3018	l	1241
		BAL6	t	2579	qr	1051
		BAL8	n	2912	m	1191
		BAL9	rs	2637	pq	1079
		BAL11	p	2739	no	1126
		BAL15	r	2656	op	1101
		L72	m	3034	l	1258
		R15	k	3232	j	1351
		L109	j	3426	i	1417
		Okapi	o	2789	no	1129
Planting Date	irrigation	Genotypes	SY		OY	
1 November (Delay Planting)	Control	BAL1	qr	2684	pqr	1072
		BAL2	x	2106	u	826
		BAL3	v	2349	s	924
		BAL6	w	2230	t	881
		BAL8	u	2405	s	939
		BAL9	v	2327	s	929
		BAL11	v	2327	s	925
		BAL15	x	2131	u	843
		L72	st	2603	r	1047
		R15	o	2818	n	1145
		L109	pq	2712	qr	1066
		Okapi	x	2155	u	837
	Restricted irrigation from pod formation stage	BAL1	z	1688	x	649
		BAL2	z	1377	z	535
		BAL3	z	1527	y	596
		BAL6	z	1358	z	527
		BAL8	z	1369	z	517
		BAL9	z	1665	x	653
		BAL11	z	1454	z	559
		BAL15	z	1148	z	440
		L72	y	1819	w	718
		R15	y	1986	v	782
		L109	z	1673	x	645
		Okapi	z	1626	x	634

SY= Seed yield (kg ha^{-1}), OY= Oil yield (kg ha^{-1})*
**Mean values of the same category followed by different letters are significant at $p \leq 0.05$ level.

Oil yield (OY)

The comparison means of planting date×irrigation×genotype effect showed that the maximum OY under planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation from pod formation) related to Okapi and L109 as 2193 and 1417 kg ha^{-1} respectively (Table 2). While in delay planting (1 November), response of genotypes to irrigation treatments was different (Table 2). For example, in both normal irrigation and drought stress conditions (restricted irrigation from pod formation) the maximum OY was observed in R15 as 1145 and 782 kg ha^{-1}, respectively (Table 2). In other words, OY was considerably affected by drought stress in both Planting date and it is a function of genotype, seed yield and slightly oil percentage generally.

Conclusion

The present study indicated that the interaction effects of planting date, irrigation and genotype on pod number per plant, seed number per pod, 1000-seed weight, seed yield, and oil yield were significant. The maximum seed yield under planting at the appropriate time (16 October), normal irrigation and drought stress conditions (restricted irrigation after pod formation stage) was observed in Okapi and L109, respectively. Among genotypes, R15 line under delay planting (1 November) and both normal irrigation and drought stress conditions (restricted irrigation after pod formation stage) showed the maximum seed yield.

Authors' contributions

A.H. Shirani Rad supervised all the research activities and criticized the manuscript. N. Shahsavari contributed to correction and manuscript preparation. N. Safavi Fard conducted the study and contributed to experiment design and samples collection.

References

Ahmadi, M. & Bahrani, M.J. (2009). Yield and yield components of rapeseed as influenced by water stress at different growth stages and nitrogen levels. *American Eurasian Journal of Agricultural and Environmental Sciences,* 5, 755–761.

Bitarafan Z. & Shirani Rad, A.H. (2012). Water stress effect on spring rapeseed cultivars yield and yield components in winter planting. *International Journal of the Physical Sciences,* 7(19), 2755-2767.

Darjani, A., Rad, A. H. S., Gholipour, S., & Haghighat, A. (2013). Investigation the effects of water stress on yield and yield components of canola winter varieties. *International Journal of Agronomy and Plant Production*, 4(3), 370-374.

Din, J., Khan, S. U., Ali, I., & Gurmani, A. R. (2011). Physiological and agronomic response of canola varieties to drought stress. *Journal of Animal and Plant Sciences*, 21(1), 78-82.

Faraji A., Lattifi N., Solatni A. & Shirani Rad, A.H. (2009). Seed yield and water use efficiency of canola as affected by high temperature stress and supplemental irrigation. *Agricultural Water Management*, 96, 132-140.

Gunasekara, C.P., Martin, L.D., French, R.J., Siddique, K.H.M. & Walton, G. (2006). Genotype by environment interactions of Indian mustard (*Brassica juncea* L.) and canola (*Brassica napus* L.) in Mediterranean-type environments: I. Crop growth and seed yield. *European Journal of Agronomy,* 25, 1-12.

Jabbari, H., Khosh, K. S. N., Akbari, G. A., Alahdadi, I., Shirani, R. A., & Hamed, A. (2016). Study of root system relationship with water relations in Rapeseed under drought stress conditions. *Journal of Crops Improvement (Journal of Agriculture)*, 18(1), 1-19.

Kauser, R., Athar, H.R. & Ashraf, M. (2006). Chlorophyll fluorescence: A potential indicator for rapid assessment of water stress tolerance in canola (*Brassica napus* L.). *Pakistan Journal of Botany*, 38(5), 1501-1509.

Mirshekari, M., Majnounhosseini, N., Amiri, R., Moslehi, A. & Zandvakili, O.R. (2012). Effects of Sowing Date and Limited Irrigation Water Stress on Spring Safflower (*Carthamus tinctorius* L.) Quantitative Traits. *Journal of Research in Agricultural Science,* 8(2), 100-112.

Modarres, R., & da Silva, V. D. P. R. (2007). Rainfall trends in arid and semi-arid regions of Iran. *Journal of Arid Environments*, 70(2), 344-355.

Nasiri, A., Samdaliri, M., Shirani Rad, A., Shahsavari, N., Mosavi Kale, A., & Jabbari, H. (2017). Effect of plant density on yield and physiological characteristics of six canola cultivars. *Journal of Scientific Agriculture*, 1, 249-253.

Pervez, M.A., Ayub, C.M., Khan, H.A., Shahid M.A. & Ashraf, I. (2009). Effect of drought stress on growth, yield and seed quality of tomato (*Lycopersicon esculentum* L.). *Pakistan Journal of Agricultural Sciences,* 46, 174-178.

Shahsavari, N., Jais H. M. & Shirani Rad, A.H. (2014). Responses of canola morphological and agronomic characteristics to zeolite and zinc fertilization under drought stress. *Communications in Soil Science and Plant Analysis*, 45(13), 1813-1822.

Shirani Rad, A.H. & A. Abbasian. (2011). Evaluation of drought tolerance in rapeseed genotypes under non stress and drought stress conditions. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 39, 164-171.

Shirani Rad, A.H., Bitarafan, Z., Rahmani, F., Taherkhani, T., Aghdam, A. M., & Nasresfahani, S. (2014). Effects of planting date on spring rapeseed (*Brassica napus* L.) cultivars under different irrigation regimes. *Turkish Journal of Field Crops*, 19(2), 153-157.

Shirani Rad, A.H., Shahsavari, N., Jais, H.M., Dadrasnia, A., Askari, A. & Saljughi, M. (2015). Fall cultivar rapeseed *(Brassica Napus* L.*)* for reduction of damage due to late season drought. *Indian Journal of Agricultural Sciences,* 85(1), 48-52.

Sinaki, J.M., Majidi Heravan, E., Shirani Rad, A.H., Noormohamadi, G. & Zarei G. (2007). The effects of water deficit during growth stages of canola (*B.napus* L.). *American-Eurasian Journal of Agricultural and Environmental Sciences*, 2(4), 417-422.

Thomas, M., J. Robertson, S. Fukai, and M. B. Peoples. (2004). The effect of timing and severity of water deficit on growth, development, yield accumulation, and nitrogen fixation of mung bean. *Field Crops Research*, 86, 67-80.

Ul-Haq, T., Anser, A., Sajid, M.N., Maqbool, M.M. & Ibrahim, M. (2014). Performance of canola cultivars under drought stress induced by restricted irrigation at different growth stages. *Soil and Environment*, 33(1), 43-50.

Wright, P.R., J.M. Morgan and R.S. Jessop. 1997. Drought stressed mustard yields more than canola due to greater leaf turgor. *Annals of Botany,* 80, 313-319.

Wright, P.R., Morgan, J.M., Jessop, R.S. & Cass, A. (1995). Comparative adaptation of canola (Brassica *napus* L.) and Indian mustard (*Brassica juncea* L.) to soil water deficits: Yield and yield components. *Field Crops Research*, 42, 1-13.

Zhang, X., Lu, G., Long, W., Zou, X., Li, F. & Nishio, T. (2014). Recent progress in drought and salt tolerance studies in Brassica crops. *Breeding Science*, 64(1), 60-73.