University of Birjand

تنش‌های محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
Vol. 14, No. 1, pp. 13-26
Spring 2021
http://dx.doi.org/10.22077/escs.2019.2220.1562

Original article

Study of ecophysiology of reaction of wintering rapeseed (*Brassica napus* L.) cultivars to end of season drought stress in delayed culture

M. Rouhi[1], M. Banayan Aval[2*], A.H. Shirani Rad[3]

1. PhD student in Agroecology, Department of Agronomy, Ferdowsi University of Mashhad, Iran
2. Associate Professors in Agroecology, Department of Agronomy, Ferdowsi University of Mashhad, Iran
3. Professor of Seed and Plant Improvement Institute (SPII), Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran

Received 19 January 2019; Accepted 8 July 2019

Extended abstract

Introduction

Rapeseed (*Brassica napus* L.) is one of the most important oilseed plants that has been ranked third in the oil production after soybeans and oil palm (Oil World, 2012). Drought stress is the most important limiting factor in the production of agricultural products in arid and semiarid regions (Debaeke and Aboudrare, 2004). Although water shortage in many developmental stages reduces the yield of rapeseed, the negative effects of stress during flowering and growth stages are much more pronounced (Sinaki et al, 2007).

Materials and methods

In order to study the ecophysiology of new winter varieties of rapeseed (six lines ready for introduction and Ahmadi's native species as control), the drought stress of the end of the season was observed in two latent cultivation conditions including the usual sowing date (11th of October) and the latent planting date (26th of October) and Irrigation was carried out in two levels including irrigation (control) and irrigation cut off from stepping stage to a factorial split plot design in a randomized complete block design with three replications in two years of cultivars 2015-2016 and 2016-2017 at the Research Institute for Correction And planting seedlings and seeds of Karaj. Planting dates and irrigation will be the main factor and the cultivars of the sub-cultivar. Data analysis was performed using SAS software. First, the Bartlett test is performed and then the combined analysis of the two-year data is tested. Comparison of mean of main effects by LSD method at 5% level and in the case of meaningful interactions, cutting and comparing the meanings were done using L.S.Means test. The results showed that the main effect of cultivar, and the effects of year on planting date and cultivar, were significant on planting date on seed oil.

Results and discussion

Results showed that in the first year and sowing date of 11th of October, the highest seed oil was obtained in the amount of 24.31%. The lowest amount was obtained in the second year and the sowing date of October 26th. In general, the seeding date of Oct. 11, in both years, had more seed oil yields.

[*]Correspondent author: Mohammad Banayan Aval; E-Mail: Banayan@um.ac.ir.

Regarding the interaction between sowing date and cultivar, results showed that the highest seed oil at the planting date of 11th of October and L72 was 54.44 percent. The lowest values were obtained on the 26th of October and the HW3 cultivar. In general, L72 had more seed oil in both dates. The results showed that the main effect of year, main effect of irrigation, main effect of cultivar, main effect of sowing date and interaction effects of planting date on cultivar on seed yield was significant. In the second year, oil yields more than the first year. In irrigation, the yield of oil was 231.2 kg/ha, which was 21% more than irrigation treatment. The results of interaction between sowing date and cultivar showed that the highest yield of seed oil (2576.6 kg/ha) was obtained on the 20th of September and L72 cultivars. The lowest values were obtained on the 5th of November and the HW3 cultivar. In general, the L72 had more seed oil yields on both dates. The results showed that the main effect of year, main effect of irrigation, main effect of cultivar, main effect of planting date and interaction effects of planting date on cultivar was significant on grain yield. In the second year, grain yield was more than the first year. In irrigation, grain yield was 4444.72 kg/ha, which was 30% more than irrigation treatment. The results of interaction between sowing date and cultivar showed that the highest grain yield was obtained at 4231.2 kg / ha in sowing date of 11th of October and L72 cultivar. The lowest values were obtained on the 26th of October and the HW3 cultivar. In general, the L72 had more seed yield on both dates.

***Keywords*:** Cultivar, Oil, Rapeseed, Yield

Table 1. Soil characteristics of experimental farm in 2015

	Deapth (cm)			
	First year		Second year	
Trait	**0-30**	**30-60**	**0-30**	**30-60**
EC (ds.m^{-1})	1.49	1.28	1.47	1.31
pH	7.9	7.5	7.7	7.6
Total neutralizing value (%)	8.63	8.75	8.54	8.1
Saturated moisture (%)	37	39	38	42
Carbon%	0.97	0.98	0.98	0.94
Total N	0.09	0.08	0.09	0.07
P (mg.kg^{-1})	14.9	15.9	15.9	16.3
K (mg.kg^{-1})	208	224	202	228
Clay%	29	26	30	28
Silt%	47	49	46	47
Sand%	24	25	24	25
Soil texture	Clay-Loam	Clay-Loam	Clay-Loam	Clay-Loam

Table 2. Varieties characteristics (000)

No.	Line or Variety	Origin	Type
1	**Promising line BAL11**	**Iran**	**Open-pollinated-Winter type**
2	**Promising line BAL6**	**Iran**	**Open-pollinated-Winter type**
3	**Promising line BAL3**	**Iran**	**Open-pollinated-Winter type**
4	**Promising line BAL8**	**Iran**	**Open-pollinated-Winter type**
5	**Promising line HW3**	**Iran**	**Open-pollinated-Winter type**
6	**Ahmadi CV.**	**Iran**	**Open-pollinated-Winter type**
7	**Promising line L72**	**Iran**	**Open-pollinated-Winter type**

Table 3. Analysis of variance of measured traits

S.O.V	df	Seeds per main silique	Seeds per secondary silique	Seeds per silique	1000-grains weight
Year (Y)	1	119.9$^{n.s}$	576.19**	305.4**	7.7**
Error a	4	18.91**	18.55**	9.18*	0.22*
Irrigation (I)	1	1529.2**	1155.5*	1335*	31.1*
Y × I	1	0.03$^{n.s}$	3.94$^{n.s}$	0.82$^{n.s}$	0.01$^{n.s}$
Planting date (P)	1	6937.27*	5279.6$^{n.s}$	6080*	139*
Y × P	1	4.91$^{n.s}$	49.38**	21.36*	0.07$^{n.s}$
I × P	1	9.93$^{n.s}$	2.96$^{n.s}$	5.93$^{n.s}$	0.37$^{n.s}$
Y × I × P	1	0.44$^{n.s}$	34.92**	10.8$^{n.s}$	0.97**
Error b	12	7.97	1.68	3.32	0.07
Variety	6	69.16**	57.19**	62.97**	1.47**
Y × V	6	0.67$^{n.s}$	0.55$^{n.s}$	0.48$^{n.s}$	0.02$^{n.s}$
I × V	6	0.9$^{n.s}$	0.89$^{n.s}$	0.66$^{n.s}$	0.03$^{n.s}$
Y × I × V	6	1.33$^{n.s}$	1.67$^{n.s}$	0.4$^{n.s}$	0.05$^{n.s}$
P ×V	6	6.94*	5.41$^{n.s}$	۴$^{n.s}$	0.17$^{n.s}$
Y × P × V	6	1.24$^{n.s}$	2.37$^{n.s}$	1.65$^{n.s}$	0.09$^{n.s}$
V × I × P	6	0.89$^{n.s}$	0.61$^{n.s}$	0.56$^{n.s}$	0.04$^{n.s}$
Y × V × I × P	6	0.46$^{n.s}$	1.93$^{n.s}$	0.88$^{n.s}$	0.03$^{n.s}$
Error c	96	5.22	4.57	2.92	0.07
Main coefficient of variation		*15.23*	*8.86*	*15.55*	*10.99*
Secondary coefficient of variation		*12.32*	*14.62*	*17.49*	*10.31*
Mean		18.54	14.62	1768.6	16.58

Table 3. Continued

S.O.V	df	Biological yield	Seed yield	Harvest index	Seed oil	Oil yield
Year (Y)	1	20941664$^{n.s}$	11370693**	281**	7.13$^{n.s}$	1843468**
Error a	4	53358570**	182485.1$^{n.s}$	8.97$^{n.s}$	1.39**	50216$^{n.s}$
Irrigation (I)	1	573264134*	44252340*	1.25$^{n.s}$	49.3$^{n.s}$	10751696*
Y × I	1	1163949$^{n.s}$	90887.65$^{n.s}$	12.9$^{n.s}$	1.68$^{n.s}$	4731$^{n.s}$
Planting date (P)	1	226588197*	161621770*	1.55$^{n.s}$	243$^{n.s}$	39690652*
Y × P	1	637439$^{n.s}$	303906.2$^{n.s}$	74.25*	8.84**	121449$^{n.s}$
I × P	1	10155998$^{n.s}$	1471314$^{n.s}$	4.87$^{n.s}$	3.94$^{n.s}$	596936$^{n.s}$
Y × I × P	1	396669$^{n.s}$	1113113$^{n.s}$	40.7$^{n.s}$	0.11$^{n.s}$	226700$^{n.s}$
Error b	12	2451590	342291.2	15.07	0.54	75686
Variety	6	25460108**	2112883**	0.64$^{n.s}$	2.54**	524561**
Y × V	6	228396$^{n.s}$	17849.3$^{n.s}$	0.61$^{n.s}$	0.08$^{n.s}$	3943$^{n.s}$
I × V	6	792504.44*	17264.81$^{n.s}$	0.23$^{n.s}$	0.07$^{n.s}$	1678$^{n.s}$
Y × I × V	6	176881$^{n.s}$	33207.6$^{n.s}$	1.4$^{n.s}$	0.06$^{n.s}$	7877$^{n.s}$
P ×V	6	3562141.7**	312494.6*	0.92$^{n.s}$	0.47*	90908*
Y × P × V	6	119617$^{n.s}$	72137.4$^{n.s}$	1.64$^{n.s}$	0.07$^{n.s}$	16302$^{n.s}$
V × I × P	6	244488.1$^{n.s}$	8767.02$^{n.s}$	1.77$^{n.s}$	0.12$^{n.s}$	3227$^{n.s}$
Y × V × I × P	6	163134$^{n.s}$	14897.8$^{n.s}$	1.37$^{n.s}$	0.14$^{n.s}$	3527$^{n.s}$
Error c	96	1437115	458596.6	35.46	0.29	95735
Main coefficient of variation		*6.75*	*10.39*	*14.89*	*14.83*	*1.65*
Secondary coefficient of variation		*6.75*	*7.95*	*17.23*	*22.75*	*1.21*
Mean		3.92	15073.7	3929.8	26.17	44.61

*: Significant at 5%. **: Significant at 1%. ns: Non-significant.

Table 4. Mean ± Mean standard error of measured traits during the years of the experiment

Year	Silique per plant	Seeds per secondary silique	Seed per Silique	1000-grains weight	Seed yield	Harvest index	Oil yield
1	163.55±4.95^{a}	16.47±0.79^{a}	17.93±0.8^{a}	4.13±0.12^{a}	4189.9±133.8^{a}	27.47±0.54^{a}	1873.41±64.74^{a}
2	148.95±4.61^{b}	12.77±0.68^{b}	15.23±0.7^{b}	3.7±0.12^{b}	3669.7±145.8^{b}	24.88±0.51^{b}	1663.9±72.24^{b}

The mean with similar letters in each column, show non- significant difference according to Duncan multiple range tests at 5% level

Table 5. Mean ± Mean standard error of measured traits under irrigation regime

Irrigation	Seeds per main silique	Seeds per secondary silique	Seed per silique	1000 seed weight	Biological yield	Seed yield	Oil yield
Control	21.59±0.8^{a}	17.26±0.7^{a}	19.4±0.7^{a}	4.35±0.1^{a}	16937±451^{a}	4444±142^{a}	2022.5±70.5^{a}
irrigation cut off	15.49±0.7^{b}	11.99±0.7^{b}	13.7±0.7^{b}	3.5±0.1^{b}	13210±414^{b}	3414.9±118^{b}	1514.7±56^{b}

The mean with similar letters in each column, show non- significant difference according to Duncan multiple range tests at 5% level

Table 6. Mean ± Mean standard error of measured traits under the influence of planting date

	Silique per plant	Seeds per main silique	Seeds per silique	1000seed weight	Biological yield	Seed yield	Oil yield
11 October	193.56±2.95^{a}	24.98±0.49^{a}	22.6±0.45^{a}	4.83±0.07^{a}	18721±293^{a}	4909.7±103.9^{a}	2254±51^{a}
26 October	118.94±2.2^{b}	12.1±0.4^{b}	10.56±0.39^{b}	3.01±0.06^{b}	11426.4±230^{b}	2949.9±82.9^{b}	1282±37^{b}

The mean with similar letters in each column, show non- significant difference according to Duncan multiple range tests at 5% level

Table 7. Mean ± Mean standard error of measured traits in different cultivars

Variety	Silique per plant	Seeds per main silique	Seeds per secondary silique	Seeds per silique
Ahmadi	155±9.64^{c}	18.32±1.67^{cd}	14.25±1.5^{cd}	16.28±1.54^{c}
BAL11	152±8.13^{cd}	17.98±1.43^{cd}	14.25±1.33^{cd}	16.12±1.36^{c}
BAL3	148±8.16^{d}	17.27±1.45^{de}	13.48±1.34^{de}	15.37±1.37^{c}
BAL6	161±9.16^{b}	19.27±1.55^{bc}	15.3±1.43^{bc}	17.28±1.46^{b}
BAL8	140±8.28^{e}	16.02±1.52^{e}	12.3±1.32^{e}	14.16±1.39^{d}
HW3	164±9.28^{b}	19.8±1.55^{b}	15.77±1.43^{b}	17.79±1.46^{b}
L72	171±10.14^{a}	21.14±1.7^{a}	17±1.54^{a}	19.07±1.6^{a}

Table 7. Continued

Variety	1000-grains weight	Biological yield	Seed yield	Seed oil	Oil yield
Ahmadi	3.89±0.24^{c}	14826±968^{c}	3847±289^{bcd}	44.6±0.3^{bc}	1733±140^{bcd}
BAL11	3.86±0.2^{c}	14689±803^{c}	3818±239^{bcd}	44.430.28^{cd}	1708±115^{bcd}
BAL3	3.74±0.21^{c}	14345±838^{cd}	3710±247^{cd}	44.3±0.28^{cd}	1657±118^{cd}
BAL6	4.05±0.22^{b}	15554±891^{b}	4064±266^{abc}	44.7±0.3^{b}	1833±130^{abc}
BAL8	3.52±0.21^{d}	13652±850^{d}	3515±256^{d}	44.1±0.28^{d}	1564±121^{d}
HW3	4.12±0.22^{ab}	15854±907^{b}	4145±266^{ab}	44.8±0.32^{ab}	1876±1313^{ab}
L72	4.26±0.25^{a}	16693±950^{a}	4406±286^{a}	45.1±0.36^{a}	2007±142^{a}

The mean with similar letters in each column, show non- significant difference according to Duncan multiple range tests at 5% level

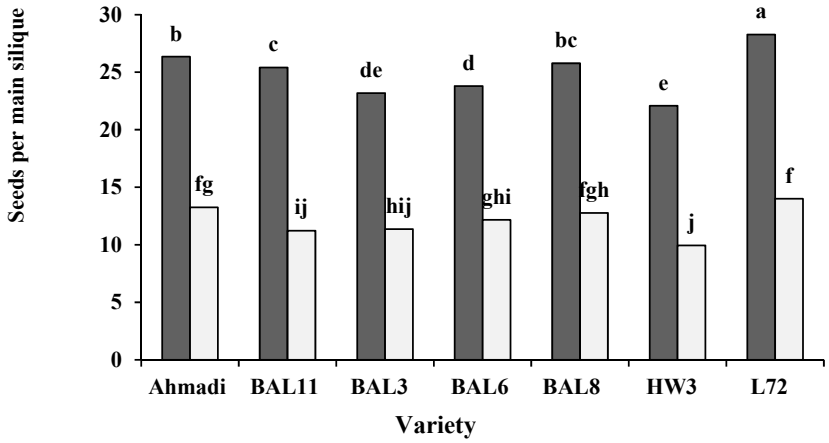

Fig 1. Effect of variety and planting date (11 October, dark columns; 26 October, pale columns) on the number of seeds per main silique (Columns with common letters do not have a significant statistical difference at 5% level).

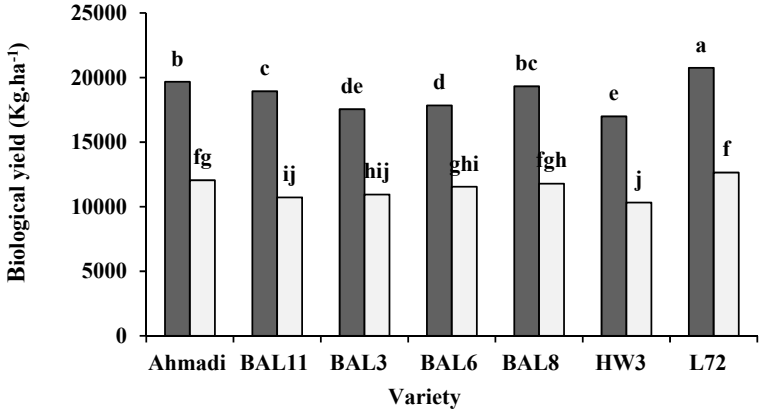

Fig. 2. Effect of variety and planting date (11 October, dark columns; 26 October, pale columns) on biological yield (Columns with common letters do not have a significant statistical difference at 5% level).

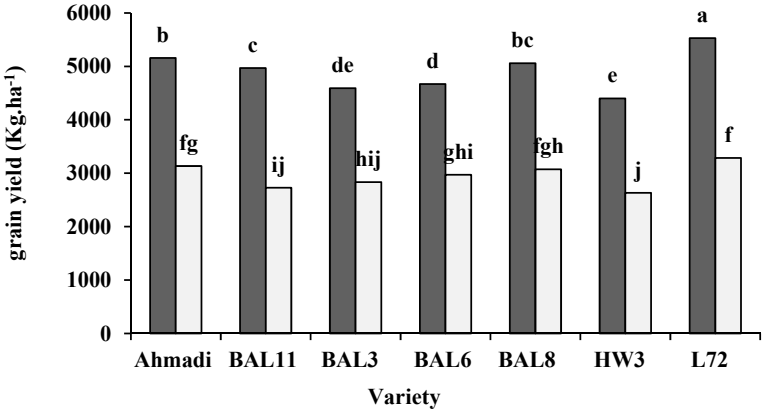

Fig. 3. Effect of variety and planting date (11 October, dark columns; 26 October, pale columns) on grain yield (Columns with common letters do not have a significant statistical difference at 5% level).

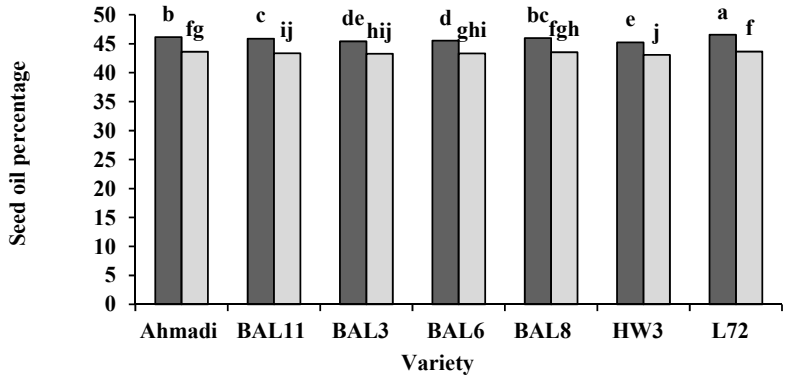

Fig. 4. Effect of variety and planting date (11 October, dark columns; 26 October, pale columns) on seed oil percentage (Columns with common letters do not have a significant statistical difference at 5% level)

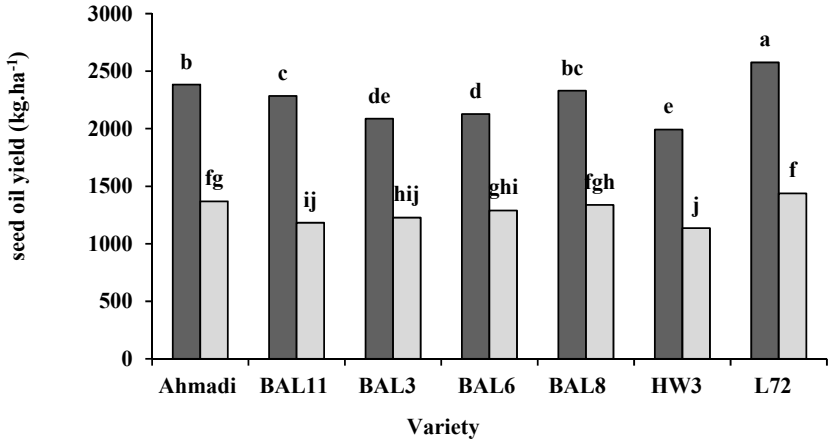

Fig. 5. Effect of variety and planting date (11 October, dark columns; 26 October, pale columns) on seed oil yield (Columns with common letters do not have a significant statistical difference at 5% level)