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Genetic variability of some traits in Rapeseed (*Brassica napus* L.) under drought stress and non-stress conditions

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Abstract. The present study was carried out to study some traits and to estimate genetic parameters in sixteen rapeseed genotypes in two conditions (irrigation and non-irrigation). Statistical analysis showed significant differences among the genotypes based on the studied traits. At maturity stage, data for 13 different characters, including chlorophyll content (SPAD), sugar solution (SS), stem size (SS), plant height (PH), days to semi-flowering (DF), oil percent (OP), oil yield (OY), thousand kernel weight (TKW), pods/branch (PB), relative water content (RWC), mean length pod (MLP), seed per pod (SP), seed yield (SY), proline, grain filling period (GFP) and sub branch per plant (SBP) were recorded from 12 randomly selected plants. Correlation analysis in non-stress condition showed the yield oil was significantly correlated with the traits PH and PB. Maximum heritability (86.69%) was obtained for OY and heritability was high for OP, OY, and PB. Also for these traits we observed high genetic advance, thus these results indicated that these traits could be improved through mass selection (in non-stress condition), while in stress condition correlation analysis showed the OY was significantly correlated with MLP and SY. In stress condition heritability was maximum (74.85%) for oil percentage, whereas low genetic advance was observed for thousand kernel weight.

Key words: *Brassica napus*, Genetic variability parameters, Heritability, Genetic gain, Genetic advance.

Introduction

Among the abiotic environmental stresses, drought is one of the most important contributors to yield reduction in semi-arid regions (Ehdaie & Waines 1993, Galiba et al. 1989, Kristin et al. 1997, Farshadfar et al. 2000). Drought is considered as one of the most important limiting factors for oil seed canola plant (*Brassica napus* L.) regarding its growth and productivity in Iran (Moradshahi et al. 2004).

Oilseed rape (*Brassica* and related species, Brassicaceae) is now the second largest oilseed crop in the world providing 13% of the world's supply. Seeds of these species commonly contain 40% or more oil content and enclose meal with 35-40% protein (Nasr et al. 2006). Rapeseed oil has a high concentration of oleic acid (60%), and contains moderate levels of linoleic acid (20%) and linolenic acid (10%) (Nasr et al. 2006, Zebarjadi et al. 2006). To plan an efficient development program, it is necessary to have a perceptive of the breeding systems coupled with statistical analysis of inheritance data (Yap & Harvey 1972; Srivastava & Dhamania 1989, Maniee et al. 2009). Nevertheless average yield of rapeseed is low compared to its genetic potential. To increase the yield, the study of genetic variability parameters provides the basis for its successful breeding program. The genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), environmental coefficient of variation (ECV) and heritability (Hb) parameters were estimated for different characters in different plants, respectively in wheat (Farshadfar et al. 2000), in rapeseed (Nazari et al. 2003), in lucerne (Farshadfar & Farshadfar, 2008) and in durum wheat (Maniee et al. 2009). To predict the selection effects precisely, heritability accompanied with genetic advance is more useful than heritability alone (Johnson et al. 1955). However, the objectives of this study were to study the genetic variability, heritability and relationships among agronomic traits in *Brassica napus* genotypes, because this information can help and provide the necessary information that could be useful in rapeseed improvement programs, especially for improving the yield character.

Materials and Methods

The current study was carried out with 16 rapeseed genotypes according to Table 1. The experiment was arranged in a randomized complete blocks design (RCBD) with 3 replications and in two different conditions (irrigated and rainfed), in a normal site where the experiment was irrigated in the following stages of growth: in stem growth stage, beginning of flowering stage and after flowering stage according to the content of evaporation from soil; but in stress conditions irrigation was not used after flowering stage. The experiment was conducted at the experimental farm of agricultural college of Razi university, Kermanshah, Iran, during 2007-2008 cropping season. Five rows in three meters length and 30 cm distant were planted for each genotype in each replication. During season growth all agronomical considerations were taken into account and standard cultural practices were followed for raising the crop. At maturity stage the data for 13 different characters, including chlorophyll content (with SPAD device), sugar solution (SS), stem size (SS), plant height (PH), days to semi-flowering (DF) (the time that about 50% of the plants from the plot started flowering), oil percent (OP), oil yield (OY), thousand kernel weight (TKW), pods/branch (PB), relative water content (RWC), mean length pod (MLP), seed per pod (SP), seed yield (SY), proline, grain filling period (GFP) and sub branch per plant (SBP) were recorded from 12 randomly selected plants. Oil yield was calculated by NMR method. The analysis of variance for different characters was measured followed by Duncan's New Multiple Range Test (DMRT) (Duncan, 1955). The coefficient of variation was calculated based on the formula suggested by Burton (1952). The genotypic and phenotypic coefficient of variation and heritability were calculated as suggested by the formula used by Singh and Chowdhury (1985) and genetic advance by Allard (1960) as well as correlation coefficient by Zaman et al. 1982. Proline and sugar solution were calculated using the methods proposed by Beats et al. 1973 and Kochert, 1978 respectively. The RWC at flowering stage was measured, for this aim young leaf samples were selected in each cultivar and replications were passed to the laboratory, immediately. Then, determinations of the fresh weight of the leaves were performed in distilled water for 24 h in refrigerator (about 5 Ċ). After 24 h passed, turgger weight of the leaves, were taken in the oven for almost 48h at ≈70 Ċ. Subsequently, RWC of the leaves was calculated as follows (Dhopte and Manuel, 2002; Azizi-e-Chakherchaman et al. 2009)

$$RWC = \left[\frac{(Wf - Wd)}{(Wt - Wd)}\right] \times 100$$

Where:

Wf: fresh weight of leaves (g)

Wd: dry weight of leaves (g)

Wt: turger weight of leaves (g)

Results and Discussion

The results of analysis of variance (ANOVA) for all traits under two conditions (stress and non-stress) are presented in Table 2 and 3. According to these tables there was a significant difference among genotypes for SPAD, sugar solution, stem size, plant height, day to semi-flowering, oil percent, oil yield, thousand kernel weight and pod per branch in non-stress site (Table 2) and for stress site we observed a significant difference for seed yield, mean length pod, oil percentage, praline content, sugar solution, grain filling period and oil yield among genotypes (Table 3). There were some reports for the same traits (Bayoumi et al. 2008, Kakaei 2009, Azizi-e-Chakherchaman et al. 2009).

Among the genotypes in non-stress condition, oil yield ranged from 573.7 to 1960 Kg/ha and the highest oil yield (1960 Kg/ha) was obtained from SLM-046 with almost the highest thousand kernel weight (3.589 g) (Table 4) and among the genotypes in stress condition, oil yield ranged from 424.5-1336 Kg/ha so that the highest yield (1336 Kg/ha) was obtained from SLM-046 (Table 5).

The maximum plant height (125.3 cm) was recorded in Dante under non-stress site and Licord produced maximum number of pod/branch (55.72). Phenotypic and genotypic coefficient of variation was highest in oil yield and environmental coefficient of variation (ECV) was highest in pod/branch (21.13%) under non-stress condition (Table 6). For stress condition, GCV, PCV and ECV were highest in oil yield (27.04%), grain filling period (35.84%) and grain filling period (30%) respectively (Table 8). Drought significantly reduced oil yield, and on the contrary sugar solution and proline content showed a significant increase under drought stress.

Evaluation of genetic parameters is the basic analysis in a breeding program (Farshadfar & Farshadfar 2008). In some studies genotypic and phenotypic coefficient of variation were reported (Naazar et al. 2003, Kashif et al. 2003). Ali (1985) also found high genotypic and phenotypic variances

Table 1. Origin and name of used genotypes.

No.	Genotype	Origin	No.	Genotype	Origin
1	Geronimo	Rostica-france	9	Talaye	Iran
2	Celecious	Svalof	10	Talent	Germany
3	Milena	Germany	11	ARC-2	U.S.A
4	Sahara	Danisco	12	Opera	Sweden
5	Sunday	Danisco	13	ARC-5	U.S.A
6	Zarfam (Reg*Cob)	Iran	14	Licord	Germany
7	Dante	Germany	15	Rainbow	Australia
8	SLM-046	Germany	16	Shiralee	Australia

Table 2. Mean squares for different characters of 16 genotypes of *Brassica napus* in non-stress condition.

S.O.V	df	SPAD	Sugar Solution	Stem Size	Plant Height	Days to Semi-Flowering	Oil Percent
Block	2	28.856	95.501	6.990	747.782	1078.583	1.756
Genotype	15	20.186*	147.007*	3.420*	183.623*	139.994*	7.379**
Error	30	9.721	67.022	1.569	83.504	68.361	1.216

S.O.V	df	Oil Yield	Thousand Kernel Weight	Pods/ Branch	Relative Water Content	Proline (μmol/gr	Grain Filling Period
Block	2	182760.966	0.555	195.247	2.690	0.034	229.271
Genotype	15	449269.643**	0.257*	268.632**	26.436^{ns}	0.024 ^{ns}	95.950 ^{ns}
Error	30	21866.658	0.117	75.020	21.088	0.024	71.296

**Significant at 1% level of probability, *Significant at 5% level of probability, ns: Non-significant

Table 3. Mean squares for different characters of 16 genotypes of *Brassica napus* in drought stress condition.

S.O.V	df	Mean length pod	Oil Percent	Proline	Sugar Solution	Grain Filling Period	Oil Yield
Block	2	0.095	2.765	1.695	2.843	1119.271	129463.733
Genotypes	15	0.700**	4.483**	4.254*	62.693*	91.022*	211728.653**
Error	30	0.253	0.452	1.913	68.907	39.893	31333.97

S.O.V	df	CC (SPAD)	Stem Size	Plant Height	Day to Semi-Flowering	Thousand Kernel Weight	Pod/Branch
Block	2	14.794	6.337	103.181	234.521	0.121	119.499
Genotypes	15	13.959^{ns}	1.958^{ns}	208.387^{ns}	92.032^{ns}	0.251^{ns}	102.067^{ns}
Error	30	23.630	1.937	107.063	65.432	0.084	137.503

**Significant at 1% level of probability, *Significant at 5% level of probability, ns: Non-significant

Table 4. Mean comparison of 16 genotypes of *Brassica napus* for different characters in non-stress condition.

	Characters								
Genotype	CC (SPAD)	Pod/ Branch	Thousand Kernel Weight (g)	Oil Yield (Kg/ha)	Oil Percent (%)	Days to Semi-Flowering	Plant Height (cm)	Stem Size (mm)	Sugar Solution (mg/l)
Geronimo	47.50^{bc}	45.28^{abc}	3.229^{bc}	1612^{bcd}	42.45^{gh}	217.3^{a}	109.5^{abcd}	6.773^{cd}	57.63^{abc}
Celecious	52.60^{ab}	50.50^{ab}	3.445^{bc}	1463^{cd}	43.02^{fgh}	206.7^{abc}	104.7^{cd}	7.587^{abcd}	42.45^{c}
Milena	50.27^{abc}	39.50^{abcde}	2.811^{c}	1498^{cd}	45.39^{abcd}	211^{ab}	101.5^{cd}	6.420^{cd}	51.38^{abc}
Sahara	49.83^{abc}	48.98^{ab}	3.442^{bc}	1731^{abc}	43.03^{fgh}	205.3^{abcd}	113.8^{abc}	7.430^{abcd}	51.17^{abc}
Sunday	53.67^{a}	46.82^{abc}	3.269^{bc}	1563^{cd}	46.08^{ab}	203.7^{abcd}	116.6^{abc}	7.777^{abcd}	61.61^{ab}
Zarfam	53.40^{ab}	30.63^{cde}	4.184^{a}	1467^{cd}	41.55^{h}	190^{d}	114.7^{abc}	7.63^{abcd}	55.61^{abc}
Dante	46.43^{c}	48.62^{ab}	3.521^{b}	1706^{abc}	43.11^{fgh}	196^{bcd}	125.3^{a}	6.120^{b}	47.25^{bc}
SLM-046	52.83^{ad}	52.13^{ab}	3.589^{ab}	1960^{a}	45.89^{abc}	191^{cd}	122.8^{ab}	9.530^{ab}	42.15^{c}
Talaye	50.83^{abc}	37^{bcde}	3.506^{b}	1693^{abcd}	43.28^{efgh}	194^{cd}	115.7^{abc}	7.143^{bcd}	61.61^{ab}
Talent	51^{abc}	38.03^{bcde}	3.375^{bc}	1848^{ab}	47.21^{a}	204^{abcd}	112.7^{abcd}	6.820^{cd}	66.17^{a}
ARC-2	55.37^{a}	42.42^{abcd}	3.537^{b}	1483^{cd}	45.91^{abc}	200^{abcd}	118.9^{abc}	7.270^{abcd}	66.53^{ab}
Opera	50.43^{abc}	38.70^{bcde}	3.709^{ab}	1716^{abc}	45.29^{abcde}	194.7^{cd}	107.3^{bcd}	8.763^{abc}	49.25^{bc}
ARC-5	53.87^{a}	23.83^{e}	3.105^{bc}	1519^{cd}	44.82^{bcdef}	203.3^{abcd}	109.2^{abcd}	7.383^{abcd}	56.32^{abc}
Licord	50.07^{abc}	55.72^{a}	3.380^{bc}	1397^{b}	43.83^{cdefg}	196.3^{bcd}	115.5^{abc}	6.353^{cd}	49.33^{bc}
Rainbow	55.90^{a}	30.650^{cde}	3.351^{bc}	573.7^{e}	44.69^{bcdef}	199.3^{abcd}	95.47^{d}	8.433^{abcd}	54.61^{abc}
Shiralee	51.73^{abc}	27.17^{de}	3.272^{bc}	578.8^{e}	43.45^{defgh}	203.7^{abcd}	105.2^{bcd}	9.663^{a}	57.74^{abc}

Table 5. Mean comparison of 16 genotypes of *Brassica napus* for characters in drought stress condition.

	Characters					
Genotype	Mean length pod (mm)	Oil Percent (%)	Proline (µ mol/gr)	Sugar Solution (mg/l)	Grain Filling Period (day)	Oil Yield (Kg/ha)
Geronimo	6.423abc	46.64a	64.56abc	68.09abcde	32.67cd	1290ab
Celecious	7.050a	46.38ad	72.52abc	71.09abcde	41.67abcd	1011abcd
Milena	5.930bcd	42.71f	61.33abc	71.30abcde	31.67d	982.8bcd
Sahara	6.483abc	45.21bcd	55.808d	68.63e	34.67bcd	1318ab
Sunday	6.193abcd	45.21bcd	80.65abc	65.71bcde	36bcd	941.2cd
Zarfam	6.203abcd	43.60bf	54.49bc	70.48cde	49.67a	1190abcd
Dante	6.570abc	43.90ef	46.62c	59.59cde	43.67abcd	1214abc
SLM-046	6.603ab	46.01abc	83.62abc	57.20abc	48.67a	1336a
Talaye	6.383abc	45.69abc	102.4a	72.07de	45.67ab	863.7d
Talent	6.237abcd	43.87ef	46.20c	73.66ab	36bcd	943.2cd
ARC-2	5.737bcd	44.40de	63.79abc	68.09abcde	39.67abcd	986.3bcd
Opera	7.083a	43.73ef	104.9ab	68.02bcde	45abc	1101abcd
ARC-5	6.190abcd	46.83a	64.87abc	72.33abcd	38.33abcd	1093abcd
Licord	5.910bcd	43.83ef	60.82abc	64.92bcde	43.33abcd	910.2cd
Rainbow	5.593cd	45.33bcd	76.30abc	67.61abc	40abcd	424.5e
Shiralee	5.293d	44.76cde	52.37c	72.09a	36bcd	457e

Table 6. Range, mean, coefficient of variation, GCV(%), PCV(%), Genetic advance(%), Genetic gain(%), Heritability(%) of different characters in 16 genotypes of (*Brassica napus*).

Character	Range	coefficient of variation (%)	ECV(%)	GCV(%)	PCV(%)	Genetic advance (%)
SPAD	46.43-55.90	6.04	6.04	3.61	7.04	1.97
Sugar Solution	42.15-66.53	15.13	15.13	9.54	17.88	5.67
Stem Size	6.12-9.66	16.49	16.49	10.34	19.46	0.85
Plant Height	95.47 -125.3	8.17	8.17	5.16	9.66	6.34
Days to Semi- Flowering	190-217.3	4.12	0.49	0.29	0.57	5.10
Oil Percent	41.55-47.210	2.46	2.46	3.19	4.03	2.33
Oil Yield	573.7-1960	9.94	9.94	25.37	27.24	72.39
Thousand Kernel Weight	2.811-4.184	9.99	9.99	6.30	11.81	0.23
Pod/ Branch	23.83-55.72	21.13	21.13	19.59	28.81	11.25

Character	Genetic gain (%)	Heritability (%)	Mean	Genotypic variance	Phenotypic variance
SPAD	3.82	26.40	51.60	3.488	13.209
Sugar Solution	10.48	28.45	54.115	26.661	93.683
Stem Size	11.29	28.20	7.59	0.617	2.186
Plant Height	5.67	28.50	108.762	33.373	116.8779
Days to Semi- Flowering	0.30	25.8	200.792	23.877	2.238
Oil Percent	5.21	62.80	44.315	2.054	3.270
Oil Yield	48.66	86.69	1488.013	142467.6617	164334.319
Thousand Kernel Weight	6.81	28.48	3.420	0.0466	0.1636
Pod/ Branch	27.45	46.24	40.989	64.537	139.557

Table 7. Correlation coefficient among different characters of *Brassiuca napus.*

Character	Oil Yield	Plant Height	Stem Size	Sugar Solution	SPAD	Thousand Kernel Weight	Pods Branch	Days to Semi-Flowering	Oil Percent
Oil Yield	-								
Plant Height	0.645**	-							
Stem Size	-0.355	-0.193	-						
Sugar Solution	-0.126	-0.034	-0.157	-					
SPAD	-0.392	-0.273	0.481*	0.209	-				
Thousand Kernel Weight	0.181	0.403*	0.304	-0.117	0.125	-			
Pod/ Branch	0.504*	0.488*	-0.315	-0.483*	-0.402*	0.030	-		
Days to Semi-Flowering	0.046	-0.197	0.152	-0.404*	0.286	0.096	0.214	-	
Oil Percent	0.188	0.017	0.088	0.258	0.350	-0.345	-0.169	-0.153	-

**Significant at 1% level of probability, *Significant at 5% level of probability

Table 8. Range, mean, co-efficient of variation, GCV(%), PCV(%), Genetic advance(%), Genetic gain(%), Heritability(%) of different characters of 16 genotypes of rapeseed *(Brassica napus*) in drought stress condition (no irrigation).

Character	Range	Coefficient of variation (%)	ECV (%)	GCV (%)	PCV (%)	Genetic advance (%)
Mean length pod	5.293-7.083	8.06	8	6.18	10.15	48.40
Oil Percent	43.60-46.64	1.50	0.476	0.821	0.949	
Proline	54.49-104.9	17.35	17.35	11.08	20.59	97.93
Grain Filling Period	31.67-49.67	30.15	30	19.61	35.84	465.2
Oil Yield	424.5-1336	17.54	19.52	27.04	33.35	409.567

Character	Genetic gain (%)	Heritability (%)	Mean	Genotypic variance	Phenotypic variance
Mean length pod	7.75	37.06	6.243	0.149	0.402
Oil Percent	1.463	74.85	44.886	1.343	1.795
Proline	12.28	28.97	66.136	0.7803	2.6933
Grain Filling Period	22.09	29.93	40.167	17.043	56.936
Oil Yield	45.19	65.74	1003.882	60131.561	91465.531

Table 9. Correlation coefficient among different characters of *(Brassiuca napus* in drought stress condition.

Characters	Oil Yield (Kg/ha)	Oil Percent	Mean length pod	Grain Filling Period (day)	Proline (µ mol/gr)	Sugar Solution (mg/l)
Oil Yield (Kg/ha)	-					
Oil Percent	0.101	-				
Mean length pod	0.684*	0.210	-			
Grain Filling Period (day)	0.172	-0.047	0.337	-		
Proline (µ mol/gr)	0.128	0.145	0.336	0.340	-	
Sugar Solution (mg/l)	-0.375	-0.019	-0.221	-0.402*	0.294	-

**Significant at 1% level of probability, *Significant at 5% level of probability

for plant height and pods per plant in *Brassica juncea*.

The highest heritability was obtained for oil yield (86.69%), oil percentage (62.80%) and pods branch per plant (46.24%) in non-stress condition. This result for the traits with high heritability, indicated that the selection for these traits will be effective because environment had little effect on them.

According to Table 6, maximum genetic advance of 72.39% followed by 11.25% was recorded in oil yield and pods branch per plant, respectively in non-stress condition. High heritability value followed by high genetic advance showed the presence of additive gene action (Kashif et al. 2003).

In stress condition the highest heritability was obtained for oil percentage (74.85%) and oil yield (65.74%). In this site a comparatively low value of heritability was observed for praline content and grain filling period (Table 8), indicating that selection for these characters would not be effective due to predominant effects of non additive gene in this population. Therefore praline content and grain filling period are not appropriate variables for selection. High heritability estimates associated with high genetic advance for plant height, pods per plant and seed yield were reported by Singh and Singh (1997). Naazar et al. 2003 reported that genotypic and phenotypic variances in rapeseed were high for pods per plant followed by plant height.

Correlation analysis in non-stress condition showed that oil yield was significantly correlated with other traits such as; plant height and pods branch (Table 7), this result showed that oil yield increasing resulted in plant height and pods branch. In stress condition the oil yield was significantly correlated with mean length pod. The pods branch was positively significantly correlated with oil yield and plant height, and negatively correlated with sugar solution and SPAD (Table 9).

The progress of a breeding program is conditioned by the magnitude and the nature of the genotypic and non-genotypic variation in various characters. Since most of the economic traits (such as yield) are complex in inheritance and are greatly influenced by various environmental conditions, the study of heritability and genetic advance is very useful in order to estimate the scope for improvement by selection. Heritability magnitude indicates the reliability with which the genotype will be recognized by its phenotype expression (Chandrabau & Sharma 1999). Finally, an estimate of heritability for different traits could be useful in breeding programs because direct selection for characters with high heritability will be effective. The results of this study showed the range of heritability and variability for some traits in rapeseed genotypes, and we can use these results in the next experiments for improving rapeseed genotypes.

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