Evaluation of seed and oil yields and their components and relationships in oilseed rape genotypes under East Azarbaijan conditions in Iran

B. Pasban Eslam

Agriculture and Natural Resources Research Center of East Azerbaijan Province, Tabriz, Iran.
Author's Email address: b_pasbaneslam@yahoo.com

Received: August 2012
Accepted: December 2012

ABSTRACT

Pasban Eslam, B. 2013. Evaluation of seed and oil yields and their components and relationships in oilseed rape genotypes under East Azarbaijan conditions in Iran. **Crop Breeding Journal 3(1): 53-59.**

Seed and oil yields, their components, and the relationships among trait performance were determined in 25 genotypes of winter type oilseed rape (*Brassica napus* L.). The experiment was carried out at the Agricultural and Natural Resources Research Center of East Azerbaijan, Iran, in two consecutive growing seasons 2009-10 and 2010-11. Significant differences were observed in plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, harvest index, and seed and oil yield. Cluster analysis divided the genotypes into two groups based on the studied traits. One group consisted of 16 genotypes with low and the other included 9 genotypes with high seed and oil yield. Based on observations, genotypes SW102, HW101, HW111, L62, L72, L139, SW104, Karaj1, and Karaj2 showed high seed and oil yields and would therefore be suitable for the Tabriz plain and areas with similar conditions and for selecting genotypes tolerant to environmental stress. A positive correlation was found between plant height and number of seeds per pod, and seed and oil yields. Number of pods per plant contributed more to seed yield among seed yield components. Harvest index and 1000-seed weight had the highest and the lowest indirect effects on oil yield, respectively. It appears that harvest index and plant height are important features for selecting winter type oilseed rape genotypes for Tabriz plain and areas with similar conditions.

Keywords: cluster analysis, oilseed rape, path analysis, seed and oil yields

INTRODUCTION

Oilseed rape (*Brassica napus* L.) genotypes with wide adaptability to environmental conditions could play a major role in Iran's oilseed crop production. Selection of high performing genotypes is very important for developing oilseed rape cultivation. According to Huhn and Leon (1985), oilseed rape seed and oil yield are the results of genotypic expression as modulated by continuous interaction with the environment. Basically oilseed rape yield depends on genotype and environmental conditions. Kuchtova *et al.* (1996) found that the response of genotypes to environmental factors differs.

Smith *et al.* (2010) reported that hybrid oilseed rape was more profitable than open-pollinated oilseed rape. Frenck *et al.* (2011) suggested that future breeding of *B. napus* L. should be based on old cultivars, since more modern varieties seem to have less potential for response to CO_2 and thus to counteract the detrimental effects of yield reducing environmental factors such as temperature and O_3. Grewal (2010) indicated that oilseed rape may be the better option for sustaining crop production and higher water use efficiency on sodic vertosols with high subsoil NaCl salinity.

Results of oilseed rape cultivation in the Tabriz plain of Iran showed that genotypes Okapi and SLM046 were more suitable for areas with late season drought stress (Pasban Eslam, 2009). Promising oilseed rape genotypes were significantly different in terms of number of pods per plant, number of seeds per pod, 1000-seed weight, and seed oil percentage under Tabriz plain climatic conditions (Pasban Eslam, 2009). Most seed yield variations in oilseed rape can be related to the number of pods per plant, number of seeds per pod, and 1000-seed weight (Chen, 1994). Peltonen-Sainio and Jauhiainen (2008) reported that environmental variation markedly affected seed yield, seed number per square meter, and duration of flowering in oilseed rape. Hamzei (2011) indicated that consumption of 450 mm of water and 120 kg of nitrogen per hectare can produce the highest seed, oil, and protein yields in oilseed rape. Number of branches, number of pods per plant, pod length, 1000-seed weight, and plant height differ among the various species and among cultivars of the same species of *Brassica* oilseed (Saran and Giri, 1987).

Generally, environmental factors have less influence on seed weight than on the number of pods per unit area and number of seeds per pod in oilseed rape (Keiller and Morgan, 1988; Jensen *et al.*, 1996). Later-sown oilseed rape crops produced fewer pods per plant and smaller seeds, but apparently there were more seeds per pod (Lutman and Dixon, 1987). In oilseed rape, the lowest number of seeds per pod is about 30, but the actual number of seeds depends on environmental factors (Mendham and Salisbury, 1995). Under soil moisture deficit conditions, supplemental irrigation of oilseed rape significantly increased harvest index and seed yield (Rao and Mendham, 1991).

Oilseed rape genotypes with higher seed oil content had higher dry matter in their reproductive organs at the end of the seed filling stage (Hua *et al.*, 2012). A study of 36 F_1 combinations derived from nine oilseed rape parents indicated that narrow-sense heritability was low for number of pods per plant and high for number of lateral branches per plant and 1000-seed weight. Thus defining the criteria for selecting this trait could be useful in breeding programs Similarly, defining the criteria for selection this trait will be effective in breeding programs (Sabaghnia *et al.*, 2010).

In spring genotypes of *B. napus* L., a significant and positive correlation has been reported between seed yield and relative growth rate (Arvin *et al.*, 2010). Evaluation of oilseed rape genotypes in Mediterranean-type environments revealed that seed yield was strongly correlated with harvest index, total number of pods per plant, 1000-seed weight, final plant height, and number of primary branches, but not with number of seeds per pod (Gunasekera *et al.*, 2006). However, The number of seeds per pod did not vary with plant height. Habekotte (1993) found that the initial number of branches and time of pod initiation during flowering had the same effect on the number of seeds per pod in oilseed rape cultivars.

The objective of the present study was to evaluate seed and oil yields, their components, and the relationship among them in order to select winter type oilseed rape genotypes with higher yield.

MATERIALS AND METHODS

This trial was carried out at the experiment station of the Agriculture and Natural Resources Research Center of East Azerbaijan, Iran (46° 2′E, 37° 58′N, 1347 masl) in two consecutive growing seasons 2009-10 and 2010-11. According to Koppen climatic classification, this location is cold and semi-arid. The average minimum and maximum annual temperatures are 2.78°C and 16.5°C, respectively. Long-tern average annual precipitation is 270 mm.

The trial was conducted using a randomized complete block design with three replications in clay loam soil with 1.5% organic matter content. Twenty-five winter oilseed rape genotypes suitable for cold areas of Iran (Table 1) were evaluated. Plot size was 5×1.2 m. The seeds were sown in the bottom of furrows in a 30+60 cm system (one pair of rows in each furrow with 30 cm spacing, and 60 cm spacing between two paired rows). Plants were thinned to 10 cm spacing within rows four weeks after sowing. Pest and weed control practices were carried out as needed throughout the growing season.

Table 1. List of the studied winter type oilseed rape genotypes.

No.	Genotype code	Cross name	No.	Genotype name	Cross name
1	L183	GA × Zarfam	14	HW104	Geronimo × Sunday
2	L170	Modena × GA096	15	HW111	Okapi ×Modena
3	L139	Sunday × Geronimo	16	HW113	Okapi ×Modena
4	L200	Modena × Okapi	17	HW114	Okapi ×Modena
5	L147	Sunday × Geronimo	18	HW112	Okapi ×Modena
6	L62	Okapi × GA096	19	SW104	Sunday ×Modena
7	L72	Orient × Modena	20	SW102	Okapi ×Modena
8	L102	Okapi × SW0756	21	Okapi (check1)	
9	L120	Okapi × Zarfam	22	Modena (check2)	
10	SW101	Geronimo × Sunday	23	Karaj1	
11	HW118	Sunday × Modena	24	Karaj2	
12	SW103	Okapi × Modena	25	Karaj3	
13	HW101	Geronimo × Sunday			

Based on soil analysis, 150, 60, and 100 kg ha^{-1} of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) were used, respectively. One third of N and all of P and K were applied pre-planting and the remaining two thirds of N were applied at stem elongation and bud appearance. Irrigation was based on soil water balance using the gravimetric method, and plants were irrigated at 35% available soil water depletion.

Plants were harvested on June 19^{th} and 23^{rd} during the first and second years of the trial, respectively. In order to control border effects, plants from the sides of each plot were removed at harvest. Finally, plant height, harvest index, seed

Table 2. Summary of combined analysis of variance of traits measured on winter type oilseed rape genotypes.

Source	df	Mean squares							
		Plant height	Pods per plant	Seeds per pod	1000-seed weight	Harvest index	Seed yield	Oil concentration	Oil yield
Year (Y)	1	1922.460	9616.007**	148.404*	1.837*	0.073**	2045401.707	134.427*	37442.137
Replication/Y	4	520.373	439.167	13.036	0.185	0.002	2411185.967	17.199	597247.579
Genotype(G)	24	434.449*	1422.535**	8.338*	0.197**	0.001*	1185314.346**	3.010	223315.397*
Y ×G	24	301.849	450.382**	10.228	0.048	0.0006	849013.484	2.611	172877.121
Error	96	232.887	175.229	6.915	0.068	0.001	557114.508	2.003	113370.064
C.V (%)		12.54	12.52	9.42	7.68	9.81	19.21	3.33	28.6

* and **: Significant at the 0.05 and 0.01 probability levels, respectively.

yield, number of pods per plant, number of seeds per pod, and 1000-seed weight were measured. Ten plants in each plot were used to determine plant height and seed yield components. Seed oil content was determined by the nuclear magnetic resonance (NMR) method.

Path analysis was used to measure both the direct and indirect effects that yield components may have on the oil yield of oilseed rape genotypes. Statistical evaluation of the data was performed using MSTAT-C and SPSS software packages.

RESULTS

Yield and yield components

Significant differences were observed in number of pods per plant, number of seeds per pod, 1000-seed weight, harvest index, and seed oil yield between the two years of the experiment (Table 2). The values of these traits, with the exception of harvest index, were higher in the second year, but due to lower plant density per plot, there was no significant yield difference between the two years (Table 3).

Among the studied winter genotypes, significant differences were observed in plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, harvest index, and seed and oil yield (Table 2). Genotypes HW101, Karaj3, HW118, SW102, and SW104 had higher plant height, while L183 and L62 had shorter plant height (Table 4).

Table 3. Means of studied traits over the two years of the experiment.

Year	Pods per plant	Seeds per pods	1000-seed weight (g)	Harvest index	Oil concentration (%)
2009-10	97.7	26.9	3.3	0.29	41.6
2010-11	113.7	28.9	3.5	0.25	43.5

Table 4. Means of traits measured on winter type oilseed rape genotypes.

Genotypes	Plant height (cm)	Pods per plant	Seeds per pods	1000-seed weight (g)	Harvest index	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
L183	106.3	100.5	27.5	3.3	0.26	3392	1433
L170	122.5	114.3	28.0	3.4	0.26	3618	1545
L139	114.3	119.8	27.9	3.5	0.28	4070	1788
L200	115.3	96.8	28.0	3.2	0.27	3202	1387
L147	107.5	102.2	25.1	3.7	0.25	3207	1346
L62	114.8	99.8	27.1	3.8	0.29	4358	1891
L72	119.5	110.2	27.2	3.4	0.27	4236	1840
L102	125.0	100.2	26.7	3.7	0.25	3708	1588
L120	114.0	84.3	27.5	3.6	0.26	3611	1516
SW101	124.8	104.8	29.5	3.4	0.27	3851	1630
HW118	133.7	118.3	28.9	3.4	0.26	3774	1631
SW103	119.3	106.0	27.4	3.4	0.29	3882	1668
HW101	139.2	95.8	30.0	3.2	0.26	4802	2057
HW104	127.7	122.0	29.2	3.1	0.26	3764	1606
HW111	116.0	116.5	29.1	3.4	0.29	4407	1876
HW113	124.3	80.8	27.2	3.1	0.24	3097	1318
HW114	126.5	95.5	28.7	3.6	0.28	3840	1673
HW112	116.7	90.5	28.2	3.1	0.27	3913	1619
SW104	129.5	94	30.0	3.4	0.27	4163	1777
SW102	132.8	113.7	26.4	3.4	0.29	4837	2046
Okapi (check1)	126.0	102.7	27.7	3.2	0.26	3948	1667
Modena (check2)	112.8	81.0	27.4	3.4	0.25	3438	1470
Karaj1	119.5	133.2	28.8	3.4	0.28	4104	1686
Karaj2	117.5	144.3	26.3	3.6	0.27	4007	1679
Karaj3	135.8	115.5	28.2	3.6	0.27	3931	1669
LSD (p=0.05)*	17.49	15.17	3.014	0.299	0.036	855.4	385.9

* Least significant difference.

The highest number of pods per plant was produced by Karaj2, Karaj1, HW104, L139, and HW118, whereas HW112, L120, and Modena had a lower number of pods per plant. In addition, SW104, HW101, SW101, HW104, and Karaj1 had a higher number of seeds per pod than other genotypes, while L147, Karaj2, and Okapi had fewer seeds per pod. Genotypes L62, L147, L102, L120, HW114, Karaj2, and Karaj3 with high amounts of 1000-seed weight are statistically located in the same group (Table 4).

Genotypes SW103, SW102, HW111, L62, L72, L139, SW104, Karaj1, and Karaj3 had high harvest index values, while HW113, L147, and L200 showed lower values (Table 4). Table 8 shows that of the 25 evaluated winter genotypes, SW102, HW101, HW111, L62, L72, L139, SW104, Karaj1, and Karaj2 had higher seed and oil yields, but lower yields were produced by HW113, L147, and L200. Genotype SW102 had the highest harvest index and more pods per plant, while HW101 had the highest number of seeds per pod and greatest plant height. Genotypes L72, Karaj1, L139, and Karaj2 had more pods per plant. Furthermore, L62 and Karaj2 showed higher 1000-seed weight, L62, SW104, and Karaj1 had more seeds per pod, and L139, Karaj1, and L62 had a higher harvest index (Table 4).

Correlations among traits

Correlation coefficients among the studied traits are shown in Table 5. Positive correlations were found between plant height and the number of seeds per pod, and seed and oil yield. The correlation coefficient between harvest index and seed and oil yield was positive. In addition, a negative correlation was found between number of seeds per pod and 1000-seed weight. The correlation between oil yield with seed oil and yield was positive.

Path analysis

The direct and indirect effects of seven traits on oil yield are shown in Table 6 by estimating the path coefficient. Seed yield and oil concentration had a positive direct effect on oil yield. Plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, and harvest index had positive indirect effects on oil yield through seed yield. Also, harvest index and 1000-seed weight had the highest and lowest indirect effects on oil yield, respectively.

Grouping the genotypes

Based on the traits mentioned above (Fig. 1), the studied genotypes were separated into two groups of 10 units by cutting cluster. One group consisted of 16 genotypes with low seed and oil yield, and the other included nine high-performing genotypes.

Table 5. Simple correlation coefficients among traits measured on winter type oilseed rape genotypes.

	Trait	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	Plant height		0.11	0.49*	-0.19	0.02	0.47*	0.22	0.47*
(2)	Pods per plant			0.01	0.14	0.35	0.34	-0.07	0.32
(3)	Seeds in pod				-0.48*	0.19	0.30	0.17	0.31
(4)	1000-seed weight					0.25	0.12	0.09	0.15
(5)	Harvest index						0.68**	0.06	0.68**
(6)	Seed yield							0.10	0.99**
(7)	Oil concentration								0.23
(8)	Oil yield								

*and **: Significant at the 0.05 and 0.01 probability levels, respectively.

Table 6. Path analysis showing direct and indirect effects on oil yield measured on winter type oilseed rape genotypes.

	Indirect effects						
Trait	Plant height	Pods per plant	Seeds per pod	1000-seed weight	Harvest index	Seed yield	Oil concentration
Plant height	(-0.026)	-0.003	-0.013	0.004	-0.001	-0.013	-0.006
Pods per plant	-0.001	(-0.005)	-0.001	-0.001	-0.002	-0.002	0.001
Seeds per pod	0.008	0.001	(0.017)	-0.009	0.003	0.005	0.003
1000-seed weight	0.005	0.003	-0.013	(0.025)	0.006	0.003	0.002
Harvest index	-0.001	-0.003	-0.002	-0.002	(-0.007)	-0.005	-0.001
Seed yield	0.463	0.335	0.295	0.118	0.670	(0.986)	0.098
Oil concentration	0.028	-0.010	0.022	0.011	0.007	0.013	(0.131)

Values in parentheses are direct effects.

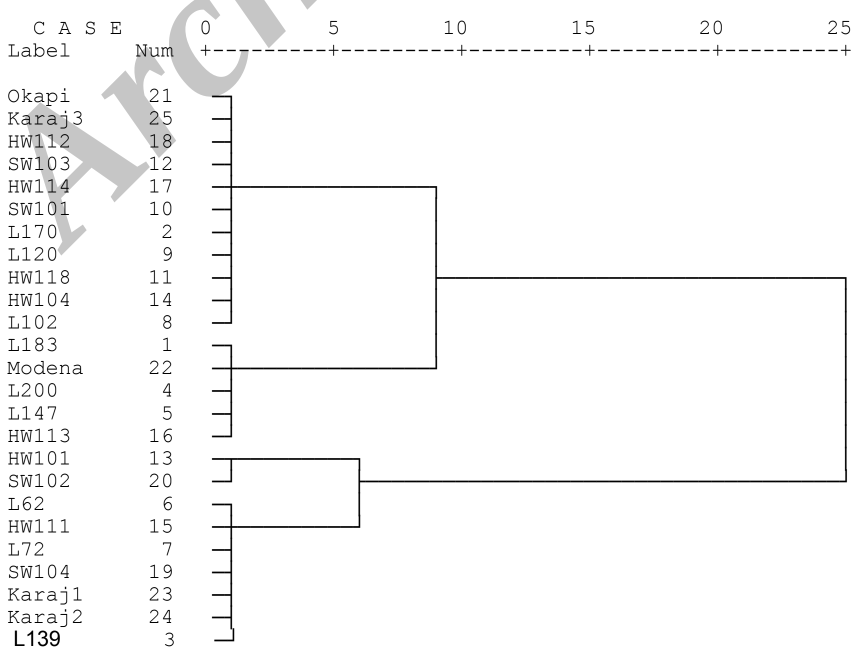

Fig. 1. Grouping of winter type oilseed rape genotypes based on plant height, pods per plant, seeds per pod, 1000-seed weight, harvest index, and seed and oil yields by using cluster analysis with the Ward method.

DISCUSSION

Results of the present study indicate that winter type oilseed rape genotypes had different values of plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, harvest index, and seed and oil yield. The main reason for the differences in seed yield in oilseed rape may be related to the number of pods per plant, number of seeds per pod, and 1000-seed weight (Chen, 1994).

Promising genotypes were significantly different in terms of the number of pods per plant, number of seeds per pod, 1000-seed weight, and oil percentage in seed at Tabriz plain (Pasban Eslam, 2009). Among the studied genotypes, SW102, HW101, HW111, L62, L72, L139, SW104, Karaj1, and Karaj2 had higher seed and oil yields and were included in the same statistical group, while genotypes HW113, L147, and L200 had lower yields.

The study of yield components in the above mentioned genotypes revealed that SW102 had the highest harvest index and more pods per plant, and HW101 had the highest number of seeds per pod and greatest plant height. After that L72, Karaj1, L139, and Karaj2 had more pods per plant. Furthermore, L62 and Karaj2 showed higher 1000-seed weight, and also L62, SW104, and Karaj1 had a higher number of seeds per pod and L139, Karaj1, and L62 had a higher harvest index.

Results of research on seed yield, seed oil content, and the evaluation of cold tolerance within exotic oilseed rape genotypes in Zanjan, Hamedan, Shahrekord, and Karaj in Iran indicated that significant differences exist among the traits mentioned above, and that the correlation between seed yield and cold tolerance was insignificant; however, a significant correlation was found between cold tolerance and seed oil content (Madani *et al.*, 2004). Seed weight was found to be less affected by environmental factors than number of pods per unit area and number of seeds per pod in oilseed rape (Jensen *et al.*, 1996; Keiller and Morgan, 1988). Oilseed, number of branches, number of pods per plant, pod length, 1000-seed weight, and plant height differ among the various species and among cultivars of the same species of *Brassica* (Saran and Giri, 1987).

In this study, positive correlations were found between plant height and number of seeds per pod, and seed and oil yields. It seems that taller genotypes support seed yield by providing more ground cover. A significant positive correlation was reported between seed yield and relative growth rate in spring genotypes of *B. napus* (Arvin *et al.*, 2010). Results also revealed that correlation coefficients of harvest index with seed and oil yield were positive. Positive correlations have been reported between seed weight per pod and pod length, and also between seed weight and harvest index in oilseed rape (Chay and Thurling, 1989).

The results of path analysis showed that plant height, number of pods per plant, number of seeds per pod, 1000-seed weight, and harvest index had positive indirect effects on oil yield through seed yield. Also harvest index and 1000-seed weight had the highest and lowest indirect effects on oil yield, respectively. It seems that harvest index can be an important characteristic for selecting winter type oilseed rape genotypes.

The 25 winter oilseed rape genotypes were separated into two groups based on the traits evaluated in the present study. It seems that nine genotypes in the second group with higher seed and oil yields could be used to select high performing winter type oilseed rape genotypes with acceptable tolerance to environmental stress.

CONCLUSIONS

It can be concluded the winter oilseed rape genotypes including SW102, HW101, HW111, L62, L72, L139, SW104, Karaj1, and Karaj2 with high seed and oil yield, are suitable for Tabriz plain and areas with similar conditions (cold and semiarid, according to Köppen climate classification). Among seed yield components, number of pods per plant showed in the highest contribution to seed yield formation than other components. Harvest index and plant height can thus be considered appropriate criteria for selecting winter oilseed rape genotypes.

REFERENCES

Arvin, P., M. Azizi, and A. Soltani. 2010. Comparison of yield and physiological indices of spring cultivars of oilseed rape species. Seed and Plant Improvement J. 25(3): 401-417.

Chay, P., and N. Thurling. 1989. Variation in pod length in spring rape (*Brassica napus*) and its effect on seed yield and yield components. J. Agric. Sci. Camb. 113: 139-147.

Chen, T. H. H. 1994. Plant adaptation to low temperature stress. Can. J. Plant Path. 16: 231-236.

Frenck, G., L. Linden, T. N. Mikkelsen, H. Brix, and R. B. Jorgensen. 2011. Increased CO_2 does not compensate for negative effects on yield caused by higher temperature and O_3 in *Brassica napus* L. Europ. J. Agron. 35: 127-134.

Grewal, H. S. 2010. Water uptake, water use efficiency, plant growth and ionic balance of wheat, barley, canola and chickpea plants on a sodic vertisol with variable subsoil NaCl salinity. Agric. Water Manage. J. 97: 148-156.

Gunasekera, C. P., L. D. Martin, K. H. M. Siddique, and

G. H. Walton. 2006. Genotype by environment interactions of Indian mustard (*Brassica junceae* L.) and canola (*B. napus* L.) in Mediterranean-type environments. 1. Crop growth and seed yield. Europ. Agron. J. 25: 1-12.

Habekotte, B. 1993. Quantitative analysis of pod formation, seed set and seed filling in winter oilseed rape (*Brassica napus* L.) under field conditions. Field Crops Res. 35: 21-33.

Hamzei, J. 2011. Seed, oil and protein yield of canola under combination of irrigation and nitrogen application. Agron. J. 103: 1152-1158.

Hua, S., H. Yu, Y. Zhang, B. Lin, H. Ding, D. Zhang, Y. Ren, and Z.H. Chen. 2012. Variation of carbohydrates and macronutrients during the flowering stage in canola (*Brassica napus* L.) plants with contrasting seed oil content. Aust. J. Crop Sci. 6: 1257-1282.

Huhn, M., and J. Leon. 1985. Phenotypic yield stability depending on plant density and on mean yield per plant of winter rapeseed varieties and of their F_1 and F_2 –generations. J. Agron. Crop Sci. 162: 172-179.

Jensen, C. R., V. O. Mogensen, G. Mortensen, J. K. Fieldsend, G. F. J. Milford, M. N. Andersen, and J. H. Thage,. 1996. Seed glucosinolate, oil and protein content of field-grown rape (*Brassica napus* L.) affected by soil drying and evaporative demand. Field Crops Res. 47: 93-105.

Keiller, D. R., and D. G. Morgan. 1988. Effect of pod removal and plant growth regulators on the growth, development and carbon assimilate distribution in oilseed rape (*Brassica napus* L.). J. Agric. Sci. Camb. 111: 357-362.

Kuchtova, P., P. Baranyk, J. Vasak, and J. Fabry. 1996. Yield forming factors of oilseed rape. Rosling Oleiste 17: 223-234.

Lutman, P. J. W., and F. L. Dixon. 1987. The effect of drilling date on the growth and yield of oilseed rape (*Brassica napus* L.). J. Agric. Sci. Camb. 108: 195-200.

Madani, H., G. Nour Mohammadi, E. Majidi, A. H. Shiranirad, and M. R. Naderi. 2004. Effects of environmental conditions on winter rapeseed cultivars and relationship between crown cell membrane stability and seed yield quality and quantity. Seed and Plant J. 20: 445-456.

Mendham, N. J., and P. A. Salisbury. 1995. Physiology: Crop development, growth and yield. Pp. 11-64. In: Kimber, D., and D. I. McGregor (eds.). *Brassica* oilseeds. CAB International.

Pasban Eslam, B. 2009. Evaluation of physiological indices, yield and its components as screening techniques for water deficit tolerance in oilseed rape cultivars. Agric. Sci. Tech. J. 11: 413-422.

Peltonen-Sainio, P., and L. Jauhiainen. 2008. Association of growth dynamics, yield components and seed quality in long-term trials covering rapeseed cultivation history at high latitudes. Field Crops Res. 108: 101-108.

Rao, M. S. S. and N. J. Mendham. 1991. Soil-plant water relations of oilseed rape (*Brassica napus* and *B. campestris*). J. Agric. Sci. Camb. 117: 197-205.

Sabaghnia, N., H. Dehghani, B. Alizadeh, and M. Moghaddam. 2010. Heterosis and combining ability analysis for oil yield and its components in rapeseed. Australian J. Crop Sci. 4: 390-397.

Saran, G., and G. Giri. 1987. Influence of dates of sowing on *Brassica* species under semi-arid rain fed conditions of north-west India. Agric. Sci. Camb. J. 108: 561-566.

Smith, E. G., M. L. Farret, G. W. Clayton, R. E. Blackshaw, S. Brandt, E. N. Johnson, K. N. Harker, J. T. O'Donovan, H. R. Kutcher, and C. Vera. 2010. The profitability of seed the F_2 generation of hybrid canola. Agron. J. 102: 598-605.