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Genetic Variation, Heritability and Path Analysis of Summer Rapeseed Cultivars

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Abstract

Six spring rapeseed varieties were studied for variability, heritability, genetic advance, correlation and path analysis of seed yield and yield components. Significant differences determined among genotypes for most of the traits indicated that there is sufficient variability available to make effective selections. Genotypic and phenotypic variances were highest for seed yield per plant followed by seed yield. Broad sense heritability estimates ranged from 0.87 to 0.99. High heritability with low genetic advance of plant height and pod length indicated the influence of dominant and epistatic effects of these traits. High heritability of seed yield per plant, seed yield, pods per main stem coupled with high genetic advance revealed that additive gene effects are important in determining these characters and could be improved through mass selection. Positive and significant correlation of seed yield with plant height, pods per main stem, seeds per pod and seed yield per plant indicated for higher seed yield. Pods per main stem, seeds per pod and plant height showed a considerable direct positive effect on seed yield per plant for almost all genotypes. These yield components can be used as selection criteria to improve seed yield of summer type rapeseed.

Key words: summer rapeseed, yield, genetic variation, heritability, correlation, path analysis

INTRODUCTION

Yield in rapeseed like other crops is a complex character and many morphological and physiological traits constitute it. Geisler [1] and Diepenbrock [2] reported that main yield components were the number of pods per plant, the number of seeds per pod and the seed weight.

Yield contributing characters are related each other in addition to relationships with yield. Progress of breeding in such characters is primarily conditioned by the magnitude and nature of variation and interrelationships among them [2]. Success in crop breeding depends also on the isolation of genetically superior genotypes based on the amount of variability present in the materials.

Several researchers [3,4,5] have emphasized the utility of genetic components estimation in prediction of response by quantitative characters to selection. Heritability estimate provides information about the extent to which a particular genetic character can be transmitted to the successive generations and helps in making selections.

In rapeseed, estimated heritability was reported as highest for seed yield, followed by the number of pods per plant and the number of primary branches per plant [6]. High heritability of seed yield per plant and seed yield coupled with high genetic advance were also reported [3,5,8].

Information on the relationship of plant characters with seed yield is crucial for breeders in order to select genotypes. The number of pod per plant is the most responsive of all yield components in rapeseed and that affects seed yield**. It is** determined by the survival of branches and pods. Seed number per pod is correlated with pod lenght [2]. Musnicki [7], Sheikh et. al [8] and Özer [9] obtained positive correlation between seed yield per plant and plant height, number of pods per main stem, number of seeds per pod. Naazar et al [5], reported positive correlation between seed yield and harvest index, seed weight and flower duration.

Simple correlation coefficients could not provide a real picture of the causative interrelationship of seed yield and other traits. Therefore path analyses are useful for partitioning correlation coefficient into direct and indirect effect interrelationship in order to obtain more and complete determination.

The objective of this study was to determine yield and yield components of different spring rapeseed cultivars, to estimate the heritable variations, to find out the relationship among yield components and the interrelationships between yield and some yield components in agro-ecological conditions of Eskişehir.

MATERIALS AND METHODS

This research was carried out during the year 2002 at research fields of Faculty of Agriculture, Eskisehir Osmangazi University, Eskişehir (39°48′ N, 30°31′ E, 789 m elevation), Turkey. The soil of the research area was sandy-loam, low in organic matter (2 %) and moderate for $CaCO_3$ (5 %).

The monthly rainfall, average temperatures and relative humidity data for Eskisehir in 2002 are shown at Table 1. The climate is semiarid and total precipitation was 343.5 mm in 2002. The long-term averages of temperature and the average temperature of the growing season were close. Precipitation amount during the growing season was 154.7 mm which was slightly higher than the long-term average. However the average of relative humidity was below the long-term average (Table 1).

Table 1. Monthly temperature, precipitation and relative humidity, Eskisehir-2002

Months	Temperature (^{O}C)		Precipitation (mm)		Relative humidity (%)	
	2002	normal*	2002	normal*	2002	normal*
April	9,3	10,1	57,4	39,2	62,4	64
May	14,7	15	44,3	46,2	51,0	63
June	19,3	18,7	11,3	34,5	49,8	60
July	23,4	21,5	35,1	13,4	50,5	54
August	21,0	21,3	6,6	7,6	56,0	56
Mean	17,54	17,32			53,9	59,4
Total			154,7	140,9		

* Long-term average, 64-year average

The experimental design was a Randomized Complete Block (RCB) with three replications using a net plot size of 5.0 x 1.2 m. Individual plots were 4 rows. Six different spring Rapeseed (*Brassica napus*) cultivars, Helios, Kosa, Prota, Spok, Semu and Star were used. The cultivars were sown on April 15, 2002, using a seed rate of 10 kg ha $^{-1}$ in 30 cm spaced lines on a well prepared seed bed. The experiment was fertilized respectively before sowing with 120 kg N ha $^{-1}$ as ammonium sulphate and 80 kg P_2O_5 ha $^{-1}$ as diammonium phosphate. The crop was irrigated twice during the growing season. First irrigation was done just after sowing while second was during flowering. The thinning was done to maintain 15 cm distance between the plants. Weeds controlled by hand weeding. The experiment was sprayed against beetles and aphids. Seed yields were taken at maturity by harvesting the central two rows of the plot by hand. At maturity, yield components such as plant height, number of branches per plant, number of pods on main stem, number of seeds per plant, pod length and seed yield per plant were recorded from 10 randomly selected plants.

The average data were subjected to the analysis of variance to test the significance level of variation among the genotypes for different characters under study [22]. Genetic parameters were computed according to the methods suggested by Singh and Chaudhry [23]. Direct and indirect path coefficients were calculated as described by Dewey and Lu [24] and Singh and Chaudhry [23].

RESULTS and DISCUSSION

Mean values of seven yield-related characters for different genotypes are shown in Table 2. The results indicated that cv. Helios, Prota and Star outyielded cv. Kosa and Spok for seed yield (Table 2). Seed yield for Helios and Prota were similar. Minimum seed yield obtained from cultivar Kosa and Spok. The results of Özer [9], İlisulu [10], Kolsarici & Başalma [11] and Anonymous [28] were comparable with our study. Oplinger et al. [12] found also similar results from cultivar Prota and Semu. Likely Sakinci [13] and Tunçtürk at al. [14] reported similar maximum seed yields from cultivar Prota and Star but seed yields of Johnson and Hanson [15], Sidlauskas [16] and Anonymous [27] were higher than our findings.

The results of Özer [9], İlisulu [10], Kolsarici & Başalma [11] and Anonymous [28] were comparable with our study. The results of plant height for the cultivars were comparable with Anonymous [29].

Seed yield per plant, pod lenght, seeds per pod and pods per main stem were effective on seed yield. Although some researchers were claim that the number of branches per plant is an important yield component [17,18] it was not as effective as declarated in our study. Kosa and Semundo have had higher branches per plant but lower seed yield in comparison with cv. Helios, Prota and Star.

The values of pod lenght, plant height, seed yield and pods per main stem were close and high among cv. Prota, Star and Semu in comparison with others. Helios for pod lenght; Prota for seeds per pod and Star for pods per main stem had better values that may give advantages in respect of seed yield.

Branches per plant were not increased with the increase of plant height. The lowest number of branches was noted in cv. Spok which had highest plant height.

Genotypic differences were highly significant for all characters at 1 % level ($p<0.01$) for the characters indicating the presence of sufficient genetic variability for effective selection to identify the superior genotypes (Table 3). Although significant results have been experienced, the variation between the genotypes were not broad for branches per plant and pod length.

The genotypes differed significantly for the recent characters. However, selection efficiency is related to magnitude of heritability and genetic advance [15].

Broad sense heritability estimates were high and ranged from 87 to 99 % for all characters. The results were high due to high genotypic influence. The highest value was obtained from seed yield per plant which is in accordance with Kuun et al [6] and Mahmood et al. [19]. Heritability estimate value for number of branches per plant was similar to the findings of Li and Guan [20]. In order to estimate the selection effects, heritability accompanied with genetic advance is rather useful than heritability alone [15]. Genetic advance was determined as percentage of the mean. The expected genetic advance,

Table 2. Comparative Performance of Different Rapeseed Cultivars (*Brassica napus* L.)

Cultivars	Plant height (cm)	Branches/plant	Pods/main stem	Seeds/ pod	Pod length(cm)	Seed yield (g/ plant)	Seed Yield (kg ha $^{-1}$)
Helios	106,3 b	5,6 cd	33,9 ab	26,3 b	6,26 a	97,9 a	1182 a
Kosa	102,7 c	6,0 a	27,8 c	24,7 c	5,86 d	65,4 b	740 d
Prota	105,1 b	5,7 bc	34,9 a	29,0 a	6,10 b	90,9 a	1183 a
Semundo 82/RH	98,8 d	5,8 b	30,1 bc	26,7 b	5,93 cd	94,2 a	843 c
Spok	108,9 a	5,0 e	27,8 c	26,7 b	5,96 c	87,2 a	739 d
Star	107,1 ab	5,5 d	35,9 a	25,0 c	6,16 b	101,7 a	1096 b
LSD Values**	**2.266**	**0,198**	**3,87**	**0.957**	**0,08**	**14.774**	**4.775**

** significant at 1 % level

expressed as a percentage of the mean, varied from 5.06 for pod length to 45.44 for seed yield per plant (table 3). Relatively very low value was shown for plant height. High expected genetic advance was observed for the number of pods per main stem and seed yield. Similar with our findings, Naazar et al. [5] and Mahmood et al. [19] had found also low genetic advance of plant height and high value for seed yield.

Heritability of seed yield per plant (0,99) coupled with high genetic advance (45.44 %) showed the additive gene effects. High heritability for this trait with high genetic advance indicated that this could be improved by mass selection. Labana et al. [3], Kuun et al [6], Sheikh et.al [8] and Naazar et al. [5] had found also high heritability estimates coupled with high genetic advance for seed yield per plant and seed yield. On the other hand, high heritability with low genetic advance of plant height and pod length indicated the influence of dominant and epistatic effects of these traits.

The phenotypic coefficient of variation (PCV) was generally higher than the genotypic coefficient of variation (GCV) for the characters, but in many cases, the two values differed only slightly. The highest values were shown for seed yield per plant and seed yield, followed by number of pods per main stem. These results are comparable with Naazar et al [5] who had found also high PCV and GCV for seed yield per plant and high GCV for the number of pods per plant. He had also found similar GCV for plant height, branches per plant and seeds per pod. The results of Akbar et al [20] were also in accordance with the findings of our study. Similarly, genotypic variance (143.65, 454.26) and phenotypic variance (165.62, 456.56) were high for seed yield and seed yield per plant (Table 3) in our study.

The results of correlation coefficient between seed yield per plant and plant height, the number of pods per main stem, the number of seeds per pod are shown in Table 4. The data show that all characters were positively and significantly correlated with seed yield per plant. Musnicki [7], Sheikh et. al [8] and Özer [7] have obtained positive correlation of the mentioned yield components with seed yield. Aygün and Algan [21] have found also similar results between seed yield per plant and seeds per pod for same cultivars.

The simple correlation coefficients were determined further by the path coefficients into direct effects and indirect effects via alternate characters (Table 5). Seed yield per plant, being the complex outcome of different characters, was considered as the resultant variable and plant height, pods per main stem and seeds per pod as causal variables. These characters have a positive direct effect on seed yield per plant for all cultivars except cultivar Star (Table 5). The direct effect of plant height on seed yield per plant was positive and the highest (1,315) followed by seeds per pod (1,276) and pods per main stem (1,210) for cultivar Prota. Our findings were similar with those of Singh and Singh [25] and of Marinkovich [26]. The direct effect of pods per main stem (0,200), plant height (0,243) and seeds per pod (0,217) for cultivar Kosa was less but positive. The direct effect of the characters on seed yield per plant of cv. Star was negative and the negative direct effect of pods per main stem has masked the positive indirect effect of plant height (0,120) and seeds per pod (1,030).

By partitioning the mutual relationship among the independent variables into direct and indirect effects on yield, it has came into account that plant height, pods per main stem, seeds per pod had the highest and positive direct effect on yield per plant almost for all cultivars except cv. Star. Therefore, these characters seem to be good selection criteria to improve seed yield.

Table 3. Genetic parameters of yield and yield components of summer rapeseed

	Range	**Mean square**	**SE**	**CD**	**CV**	σ^2g	σ^2p	h^2	**PCV**	**GCV**	**GA**
Plant height (cm)	97.9-111.3	25.05**	1,02	3,22[1] 2,27[2]	1,22	12,43	12,94	0,96	3,43	3,36	6,79
Branches/ plant	4.9-6.1	29.76**	0,09	0,28[1] 0,2	0,46	0,11	0,12	0,97	6,12	6,02	12,19
Pods/main stem	24.1-38.4	8.64**	1,73	5,5[1] 3,87[2]	3,77	11,49	12,99	0,88	11,36	10,68	20,7
Seeds/ pod	24.4-29.9	25.71**	0,43	1,36[1] 0,96[2]	1,02	2,27	2,37	0,96	5,83	5,71	11,53
Pod length (cm)	5.8-6.2	35.20**	0,04	0,12[1] 0,08[2]	0,18	0,023	0,02	0,97	2,53	2,49	5,06
Seed yield/ plant	61.1-105.2	7.54**	2,14	6,79[1] 4,78[2]	2,67	454,26	456,56	0,99	22,17	22,11	45,44
Seed Yield kg ha^{-1}	72.2-119.8	198.99**	6,63	21,01[1] 14,78[2]	8,58	143,65	165,62	0,87	14,37	13,38	22,99

(SE) St.Error, (CD)Critical Difference [1] %5, [2] %1; (CV)Coefficient of variation; Genotypic variances (σ^2g) ;Phenotypic variances (σ^2p); (h^2) Broad-sense heritability; (GA) genetic advance (% of mean); (PCV) phenotipic coefficient of variation, (GCV) genotypic coefficient of variation; ** significant at 1 % level

Table 4. Simple correlation coefficients of seed yield per plant in summer type rapeseed cultivars

Cultivars	Characters	Plant height (cm)	Pods/main stem	Seeds/ pod
Helios	Plant height (cm)			
	Pods/main stem	0,92**		
	Seeds/ pod	0,86**	0,95**	
	Seed yield/ plant (g)	0,99**	0,94**	0,88**
Kosa	Plant height (cm)			
	Pods/main stem	0,84**		
	Seeds/ pod	0,89**	0,95**	
	Seed yield/ plant (g)	0,92**	0,97**	0,98**
Prota	Plant height (cm)			
	Pods/main stem	0,92**		
	Seeds/ pod	0,97**	0,95**	
	Seed yield/ plant (g)	0,99**	0,86**	0,94**
Semu	Plant height (cm)			
	Pods/main stem	0,95**		
	Seeds/ pod	0,98**	0,97**	
	Seed yield/ plant (g)	0,83**	0,8**	0,82**
Spok	Plant height (cm)			
	Pods/main stem	0,90**		
	Seeds/ pod	0,95**	0,97**	
	Seed yield/ plant (g)	0,99**	0,95**	0,97**
Star	Plant height (cm)			
	Pods/main stem	0,97**		
	Seeds/ pod	0,96**	0,97**	
	Seed yield/ plant (g)	0,94**	0,96**	0,99**

r%5= 0,63*; r%1=0,76**

Table 5. Path coefficient values estimated for seed yield per plant and other three characters

			Indirect effects			Total	Total
		Direct effect	Plant height	Pods/main stem	Seeds/pod	**indirect effect**	**effect**
Helios	Plant height	0,743		0,354	-0,107	0,25	0,99
	Pods/main stem	0,680	0,380		-0,120	0,26	0,94
	Seeds/pod	0,639	0,365	-0,120		0,25	0,88
Kosa	Plant height	0,243		0,431	0,245	0,68	0,92
	Pods/main stem	0,200	0,510		0,260	0,77	0,97
	Seeds/pod	0,217	0,488	0,276		0,76	0,98
Prota	Plant height	1,315		-0,300	-0,029	-0,33	0,99
	Pods/main stem	1,210	-0,320		-0,030	-0,35	0,86
	Seeds/pod	1,276	-0,306	-0,030		-0,34	0,94
Semu	Plant height	0,668		0,080	0,082	0,16	0,83
	Pods/main stem	0,630	0,080		0,088	0,17	0,80
	Seeds/pod	0,655	0,082	0,083		0,17	0,82
Spok	Plant height	0,801		0,401	-0,212	0,19	0,99
	Pods/main stem	0,720	0,450		-0,220	0,23	0,95
	Seeds/pod	0,761	0,432	-0,220		0,21	0,97
Star	Plant height	-0,190		0,119	1,014	1,13	0,94
	Pods/main stem	-0,190	0,120		1,030	1,15	0,96
	Seeds/pod	-0,190	0,119	1,057		1,18	0,99

REFERENCES

[1] Geisler, G. 1978. Die Ertragsstruktur vom Raps. 7.Ausgabe. 34. Kiel.

[2] Diepenbrock, W. 2000. Yield Analysis of Winter Oilseed Rape (*Brassica napus* L.): a Review. Field Crops Research 67, 35-49.

[3] Labana, K. S., B. D. Chaurasia and B. Singh. 1980. Genetic Variability and Inter-Character Associations in the Mutants of Indian Mustard. Indian J. Agri. Sci.50:803-806.

[4] Ali, N. 1985. Genetic Variability and Correlation Studies in *Brassica juncea*. Pak. J. Bot. 7 (2):297-303.

[5] Naazar, A., F. Javidfar, E. Jafarieh, M. Mirza, 2003. Relationship Among Yield Components and Selection

Criteria for Yield Improvement in Winter Rapeseed (*Brassica napus* L.). Pakistan Journal of Botany, 35(2):167-174.

[6] Kuun, B. S., I. H. Kin, 1977. Investigations on Correlations Co-efficient, path Co-efficient and Heritabilities of the Principlal Characters of Rape and Their Effects on Yield. Korean J. Breed, 9:58-64.

[7] Musnicki, C. 1974. Investigation on Native and Foreign Winter Rape Varieties in Poland. Proceedings 4. Internationaler Rapskongress. 201-207. 4-8 Juni 1974. Giessen

[8] Sheikh, F. A., A. G. Rather, S. A. Wani. 1999. Genetic Variability and Inter-Relationship in Toria (*Brassica campestris* L. *var.toria*). Advances in Plant Sciencs, 12(1):139-143.

[9] Özer, H., 1996. Erzurum Ekolojik Koşullarında Bazı Kolza (*Brassica napus ssp oleifera* L.) Çeşitlerinin Fenolojik Özellikleri ile Verim ve Verim Unsurları Üzerine bir Araştırma. Turkish J. of Agriculture and Forestry. 319-325.

[10] İlisulu, K., 1970. Fransa ve Almanya'dan Getirilen Kolza Çeşitlerinin Ankara İklim ve Toprak Şartları Altında Adaptasyon Durumları, Tohum Verimleri ve Diğer Bazı Özelliklerinin Tespiti. Ankara Üniversitesi Ziraat Fakültesi Yıllığı. Cilt:20, Fasikül 1. Ankara.

[11] Kolsarici, Ö., D. Başalma. 1988. Yabancı kökenli Yazlık Kolza (*Brassica napus* ssp. *oleifera* L.) Çeşitlerinde Tohum Verimi ve Yağ Verimi ile Bin Tohum Ağırlığının Saptanması. Ankara Üniversitesi Ziraat Fakültesi Yıllığı. Cilt:39, Fasikül 1-2. Ankara.

[12] Oplinger, E. S., L. L.Hardman, E. T. Gritton, J. D. Doll and K. A. Kelling. 2000. Canola (Rapeseed), Alternative Field Crops Manual. http//www.hort.purdue.edu/newcrop/afcm/canola.html

[13] Sakinci, İ., 2000. Effects on Yield and Yield Componens of Some Spring Rapeseed Varieties Grown in Different Row Distances in Van Conditions. MS thesis. Ankara University. 47 p.

[14] Tunçtürk, M., İ. Yılmaz, M. Erman, R. Tunçtürk, 2005. Yazlık Kolza Çeşitlerinin Van Ekolojik Koşullarında Verim ve Verim Özellikleri Yönünden Karşılaştırılması. Tarım Bilimleri Dergisi, 11(1) 78-85.

[15] Johnson, B. L., B. K. Hanson, 2003. Row Spacing Interaction on Spring Canola Performance in the Northern Great Plains, Agronomy J. 95:703-708.

[16] Sidlauskas, G., S. Bernotas, 2003. Some Factors Affecting seed Yield of Spring Oilseed Rape (*Brassica napus* L.), Agronomy Research 1(2), 229-243.

[17] Schuster, W. 1979. Rapszucht im Aufwind, DLG-Mitteilungen, 94, 881-883.

[18] Marinkovic, R. 1992. Path Coefficient Analysis of Some Yield Components of Sunflower. Euphytica, 60:201-205.

[19] Mahmood, M, S. Ali, M. Iqbal, Anwar, 2003. Genetic Variability and Heritability Estimates in Summer Mustard (*Brassica juncea*), Asian Journal of Plant Sciences 2(1), 77-79.

[20] Akbar, M., T. Mahmood, M. Yaqub, M. Anwar, M. Ali, N. Iqbal, 2003. Variability, Correlation and Path Coefficient Studies in Summer Mustard (*Brassica junceae* L.), Asian Journal of Plant Science, 2(9), 696-698.

[21] Aygün, H. and N. Algan, 2004. Bazı Fizyolojik Yazlık Kanola (*Brassica napus ssp.oleifera* L.) Genotiplerinde Verim ve Verim Komponenetleri Arasındaki İlişkiler. Ege Üniv. Ziraat Fak. Dergisi 41(2):69-76.

[22] Steel, R. G., J.S.Torrie, 1980. Principles and Procedures of Statistics. Abiological Approach. Second Edition. McGraw Hill Book Company Inc., New York, Toronto.

[23] Singh R. K. and B. D. Chaudhry, 1979. Biometrical Methods in Quanitative Genetic Analysis. Kalyani Publ., New Delhi.

[24] Dewey, D. R. and K. H. Lu, 1959. A Correlation and Path-Coefficient Analysis of Components of Crested Wheatgrass Seed Production. Agronomy J. 51:515-518.

[25] Singh, M., G Singh, 1997. Correlation and Path Analysis in Indian Mustard (*Brassica juncea L.*) Under Mid Hills of Sikim. J. Hill Res. (India). 10 (1):10-12.

[26] Marinkovic, R., A. M. Jeromela, J. Crnobarac, J. Lazarevic, 2003. Path Coefficient Analysis of Yield Components of Rapeseed (*Brassica napus*). 11th Intern. Rapeseed Congress, Copenhagen, DK, 6-10 07 2003.

[27] Anonymous, 2005. Ergebnisse der Landessortenversuche zu Sommerölfrüchte. http://www.agrarnet-mv.de

[28] Anonymous, 2006. Versuchsbericht Landessortenversuche 2006.Landesanstalt für Landwirtschaft, Forsten und Gartenbau. http://lsa-st23.sachsen-anhalt.de

[29] Anonymous, 2008. 2005 Pacific Northwest Spring Canola Variety Trial Results. http://www.ag.uidaho.edu