Combining ability of some rapeseed (*B. napus* L.) varieties

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Abstract

The objects of the study were the combining ability (CA) of five rapeseed (*B. napus* L.) varieties, mode of inheritance of oleic and linoleic acid content in the F_1 generation and components of genetic variability. Diallel crosses without reciprocals were made between five varieties. The plants used as mothers were turned male sterile by hand.

Diallel analysis was done according to Griffing (1956) (Method 2, Model 1). The mode of inheritance was assessed according to Borojević (1965), while the analysis of components of genetic variability was done according to Jinks (1954). In the inheritance of both characters, positive heterosis, dominance of the better parent, dominance of the poorer parent and intermediacy were expressed. Additive components of genetic variability played the more important role in the inheritance of both characters. In the process of inheriting seed oil content, dominant genes in the parents prevailed over recessive ones.

Key words: inheritance, linoleic acid, oleic acid, aditive and dominant gene action.

Introduction

Rapeseed (*B. napus* L.), in particular its winter form, is receiving increasing attention by farmers in Serbia. The most important reason for this lies in the fact that the farm price of the commercial seed of this crop has become higher even than that of soybean and sunflower seeds. Such high farm price springs from the need for the production of biodiesel, as rapeseed oil is regarded as providing better quality raw material than any other oil crop. Based on EU regulations on the minimum percentage of biodiesel that must be mixed into D_2 diesel fuel and D_2 consumption in Serbia, the present needs for biodisel in Serbia are estimated at 50,000 t. As the average seed yield of rapeseed is currently at 2-2.5 t/ha, rapeseed production should be established on over 60,000 ha in the country in order to satisfy the present domestic demand for this crop. Rapeseed oil that does not contain erucic acid can also be used for human consumption.

Oil obtained from the seeds of rapeseed varieties and hybrids grown in Serbia is 3.65-4.91% palmitic acid (16:0), 1.06-1.90% stearic (18:0), 59.90-67.90% oleic (18:1), 15.60-20.90% linoeic (18:2), 6.45-10.95 linolenic (18:3), 0.0-0.67% arachidonic (20:0), 1.07-3.24% eicosenoic (20:1), and 0.0-0.40% behenic acid (22:0). The erucic acid content depends on whether the variety or hybrid belongs in maturity group 0 or 00 (Marinković, unpublished data).

Recent studies by nutritionists (Grundy, 1986; Yodice, 1990) have led to the appearance of a new nutritional philosophy that recommends maximum use of monounsaturated acids in the human diet. According to Grundy (1986), the consumption of fat rich in oleic fatty acid can effectively reduces cholesterol levels, since this acid reduces the levels of lipoproteins, which carry low density cholesterol around the bloodstream, without having any effect on the levels of triglycerides or lipoproteins carrying high density cholesterol.

Linoleic acid (vitamin E) is an important essential polyunsaturated fatty acid that also reduces blood cholesterol levels and is a main component of cell membranes. As it is necessary for growth and reproduction and as a protection from excessive water loss and radiation injury (Anonymous, 1968), it must be taken in through food, because the human organism is incapable of synthesizing it from other fatty acids.

The objective of this study was to investigate the combining abilities of several rapeseed varieties and the mode of inheritance and gene action for linoleic and oleic acid contents.

Materials and methods

Genetic material used in this study consisted of five rapeseed varieties (Banaćanka, Orkan, Valeska, Aligator and Alaska). During 2003, they were subjected to half diallel crosses (no reciprocals). Stamens on plants used as the female parent were removed manually in the early morning hours to prevent any potential self pollination.

A trial with the F_1 generation hybrid combinations and the parents was set up in 2004 at the Rimski Šančevi Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad. The plants were sown on a chernozem soil in three replications using a randomized block design. The rows were 5 m long and 25 cm apart with a 5-6 cm spacing between the plants. The seeds of the hybrids and parents were planted manually in four rows.

Fatty acids in the oil were determined as methyl esters using gas chromatography (Garces and Mancha, 1993). Analysis of variance was done according to Hadživuković (1973), while the mode of inheritance was assessed using the test of significance of generation means relative to parental average (Borojević, 1965).

Analysis of variance of general (GCA) and specific (SCA) combining ability was done according to Griffing (1956), Method 2, Model 1.

Results

Significant differences in oleic acid content were found among most of the varieties and their combinations (C 18:1). Among the varieties, the highest value for this trait was found in Valeska (71.60%) and the lowest in Aligator (67.64%). Among the F_1 hybrids, the highest oleic acid content was recorded in the Banaćanka×Orkan combination (72.41%).

In the inheritance of oleic acid content in the F_1 generation, positive heterosis was found in one hybrid combinations, dominance of the better parent in two, and dominance of the poorer parent also in one. In the rest of the combinations, the mode of inheritance could not be determined, as there were no significant differences between the parents (Tab. 1).

Analysis of the combining abilities showed highly significant values for both GCA and SCA. However, genes with nonadditive effects played the predominant role in the inheritance of this trait (Tab. 2). This finding was supported by the values of genetic components calculated from the variance components, as the value of the dominant component ($\delta^2D=\delta^2S=1.84$) was higher than that of the additive one ($\delta^2A=2\delta^2g=0.31$).

Positive GCA values were found in three and negative ones in two varieties (Tab. 3). The variety Orkan had the highest GCA value and the difference compared to the other varieties was significant.

The relatively low variance of SCA (δ^2s_i) found in Banaćanka and Alaska indicate that these varieties pass down their high ability for a high oleic acid content evenly, whereas the high variance of SCA in Orkan shows that there are specific combinations of this variety with other varieties that will have considerably higher oleic acid contents than expected, and conversely, that there are other such combinations that will have considerably lower oleic acid contents than expected. Because of this, Banaćanka and Alaska are probably superior to Orkan when used in the development of synthetics, while Orkan is superior to the other two genotypes when it comes to obtaining specific combinations with a higher oleic acid content (Tab. 5).

The linoleic acid content (C 18:2) of the varieties used in the study ranged from 14.94% (Valeska) to 19.06% (Aligator). Among the hybrid combinations, the highest value of this trait was found in the hybrid Aligator×Valeska.

In the inheritance of linoleic acid content in the F_1 generation, heterosis, intermediacy, and dominance of the better or poorer parent were manifested (Tab. 1).

As highly significant differences for GCA and SCA were obtained, it can be concluded that genes with additive and dominant effects play the important roles in the inheritance of this trait. According to the values of genetic components calculated from the components of variance, the additive component ($\delta^2A=2\delta^2=2.28$) was considerably higher than the dominant one ($\delta^2D= \delta^2s=0.41$), meaning that genes with additive effects played the predominant role in the expression of this trait. Similar results have been reported by Marjanović – Jeromela et al. (2001).

The GCA effects were highly significant in four varieties. In two of the varieties they were negatively so and in two positively.

The best general combiner, the variety Aligator, had a considerably lower value of SCA variance than the variety Alaska and can hence be successfully used for developing synthetics. Alaska, thanks to its higher SCA variance value (δ^2s_i), can be successfully used for the obtainment of specific combinations with increased levels of linoleic acid (Tab. 5).

Highly significant positive SCA effects were observed in one hybrid combination, while two had significant positive SCA effects. Two more combinations had positive SCA effects, while five had negative ones. (Tab. 4). The highest such effects were found in a combination that included the poorest general combiner for this trait, the variety Orkan.

Conclusion

In the inheritance in the F_1 generation of the fatty acids studied, positive heterosis, dominance of the better parent, dominance of the poorer parent, and intermediacy manifested themselves.

The variety Orkan was found to be more suitable for obtaining specific combinations with an increased oleic acid content, while the variety Alaska was determined to be more suited for developing specific combination with increased linoleic acid levels.

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Table 1. Mean oleic and linoleic acid of parents (in bold) and their F_1 hybrids in a 5×5 diallel cross of oilseed rapes.

Parents	Characters	Banaćanka	Orkan	Valeska	Aligator	Alaska
Banaćanka	Oleic acid	**70,01**	72,41^{h}	69,87	67,80^{d-}	69,32
	Linoleic acid	**16,83**	15,42^{d-}	17,40^{d+}	18,25^{d+}	17,51^{d+}
Orkan	Oleic acid		**70,69**	67,47	70,65^{d+}	71,01
	Linoleic acid		**15,61**	16,14	16,53^{h}	16,20^{i}
Valeska	Oleic acid			**71,60**	70,21^{d+}	68,90
	Linoleic acid			**14,94**	16,79^{i}	17,87^{d+}
Aligator	Oleic acid				**67,64**	67,93
	Linoleic acid				**19,06**	19,14^{d+}
Alaska	Oleic acid					**68,88**
	Linoleic acid					**17,97**

LSD 0,05=1,61 0,78
0,01=2,17 1,05

Table 2.Analysis of variance for general (GCA) and specific (SCA) combining ability effects in oilseed rapes.

Source	d. f.	Oleic acid			Linoleic acid		
		SS	MS	F	SS	MS	F
Gca	4	10,78	2,70	8,72**	17,91	4,48	61,80**
Sca	10	21,47	2,15	6,95**	4,87	0,49	6,72**
Error	28	8,65	0,31		2,03	0,07	
GCA/SCA ratio			1,26			9,14	
$\delta A=2\delta^2 g$			0,31			2,28	
$\delta D=2\delta^2 s$			1,84			0,41	

Table 3.Estimates of general combining ability effects for two traits in oilseed rapes

Parent	Oleic acid	Linoleic acid
Banaćanka	0,24	-0,01
Orkan	0,74*	-0,96**
Valeska	0,27	-0,60**
Aligator	-0,84**	0,94**
Alaska	-0,41	0,63**
(g_i-g_j)	0,30	0,14
LSD 0,05	0,82	0,40
0,01	0,61	0,30

Table 4. Estimates of specific combining ability effects for oleic and linoleic acid contents in oilseed rapes

Parent	Characters	Sca effects				
		Orkan	Valeska	Aligator	Alaska	
Banaćanka	Oleic acid	1,81*	-0,27	-1,22	-0,14	
	Linoleic acid	-0,65	0,96**	0,27	-0,16	
Orkan	Oleic acid		-3,17**	1,12	1,05	
	Linoleic acid		0,66*	-0,49	-0,50	
Valeska	Oleic acid			1,16	-0,59	
	Linoleic acid			-0,59	0,79*	
Aligator	Oleic acid				-0,46	
	Linoleic acid				0,53	
	Standard errors:		Oleic acid		Linoleic acid	limitations
	SE $(S_{ij}-S_{ik})$		0,73		0,35	i≠j, k; j≠k
	SE $(S_{ij}-S_{kl})$		0,66		0,32	i≠j, k; l; j≠k, l; k≠l
	LSD 0,05		1,84		0,89	
	0,01		1,36		0,66	

Table 5. Estimates of general and specific combining ability variances in oilseed rapes.

Parent	Characters	δg_i^2	δs_i^2	Individual basis (δe^2)	Mean δ^2
Banaćanka	Oleic acid	0,02	4,62	0,93	0,31
	Linoleic acid	-0,0	1,39	0,22	0,07
Orkan	Oleic acid	0,53	15,44	0,93	0,31
	Linoleic acid	0,91	1,30	0,22	0,07
Valeska	Oleic acid	0,03	11,58	0,93	0,31
	Linoleic acid	0,35	2,28	0,22	0,07
Aligator	Oleic acid	0,67	4,06	0,93	0,31
	Linoleic acid	0,88	0,89	0,22	0,07
Alaska	Oleic acid	0,13	1,44	0,93	0,31
	Linoleic acid	0,39	1,13	0,22	0,07