RAPESEED BREEDING FOR BETTER OIL AND MEAL QUALITY IN POLAND

J. Krzymański

Winter rape (Brassica napus L.) is practically the only oil plant which can be grown profitably in agro-climatic condition of Poland. For this reason the problem of this quality plays an important role. The lower seed value of rape is determined mainly by two factors - high erucic acid content in oil and toxic properties of thioglucosides (glucosinolates) which occur in meal. These two undiserable factors can be changed only in small degree by modifications in oil industry technology. It looks now the best solution of the problem can be obtained with genetical means breeding of new varieties of rape with improved chemical composition. Especial research project was made by Oil Crop Department of Institute of Plant Breeding and Acclimatization (IHAR). Minister of Agriculture accepted it and called research groups for its realization. Extensive and comprehensive researches and breeding works are now conducted on this field in Poland by Oil Crop Department of IHAR in Poznań and four collaborating Plant Breeding Stations. Institute of Food and Nutrition and Institute of Oil Industry are also taking part in this investigation.

Elaboration of method for fatty acid composition analysis by quantitative paper chromatography (KRZYMANSKI, 1961, 1965 a) allowed to undertake genetical researches and rape breeding for low erucic acid content in seed oil. This method was replaced later by gas chromatography (BYCZYNSKA & KRZYMANSKI, 1968; KRZYMANSKI & DOWNEY, 1969). Works on thioglucoside required also certain and proper analytical method. Different methods were examined and a new modification of Youngs-Wetter's methods were proposed (BYCZYNSKA, 1974 a).
This method, based on gas chromatography, makes possible the estimation of individual isothiocyanates and individual oxazolidinethiones in seed meal. It is well adapted for needs of breeding and genetic investigation. Oil content in seeds is not analysed now by destructive and quick method based on nuclear magnetic resonance measurement (KRZYMANSKI, 1970 b).

Survey of all varieties and strains of winter rape in our collection showed that we had none winter form low in erucic acid or thioglucoside content (BYCZYNSKA, 1974 b; KRZYMANSKI, 1965 b). For this reason it was necessary to use spring forms for obtaining essential genetic variability. The following lines were genetical sources of desired traits in our researches and breeding works:

1. zero erucic line selected from "Liho" variety of spring rape in Canada (STEFANSSON et al., 1961);
2. low erucic line selected from "Bronowski" variety of spring rape in Poland (KRZYMANSKI, 1966; KRZYMANSKI et al., 1967);
3. lines with very low thioglucoside content selected from "Bronowski" variety of spring rape (FINLAYSON et al., 1973; KRZYMANSKI, 1970 a, c).

Investigation was realized on inheritance of erucic acid content in rape seed oil (KRZYMANSKI et al., 1967; KRZYMANSKI & DOWNEY, 1969; KRZYMANSKI, 1970 a) and on inheritance of thioglucoside content in rape seed (KRZYMANSKI, 1970 a, c). The results obtained were conformable to the published data of other authors (HARVEY & DOWNEY, 1964; KONDRA & STEFANSSON, 1965, 1970) (Based on these results) it can be concluded:

1. erucic acid content in rape seed oil is a hereditary trait controlled by embryo genotype;
2. erucic acid content is controlled by one or two pair system - the zero or low erucic forms represents 1/4 or 1/16 of the F_2 generation depending on cross combination;
3. there are alleles or pseudoalleles controlling different levels of erucic acid acting in an additive manner without distinct domination;
4. thioglucoside content in rape seed is controlled mainly by the maternal plant genotype in respect of both quantity and quality;
5. the trait of high thioglucoside content is a dominant one in reference to total content of these compounds, but for individual thioglucosides different results were obtained. Overdominancy was observed in the case of pentenyl isothiocyanate dominance for butenyl isothiocyanate and incomplete dominance for oxazolidinethiones;
6. a differentiation in thioglucoside composition was also observed in segregating generations of hybrids.

Low erucic or low thioglucoside strains of winter rape were obtained by crosses between winter varieties of rape and above mentioned lines of spring rape. But these desired traits were strongly linked with many other traits typical for spring forms. These traits were usually unfavourable and caused that new strains had much lower agricultural value than normal old varieties which have been cultivated till now. These strains make only a row material which needs further improvement especially for better vigor, higher yielding ability and better winter hardiness. We try to achieve this goal by using breeding methods based on backcrossing and intensive selection in segregating generations.

Selection works are carried out in natural field conditions. Single plant selection is followed by strain selection based on accurate field trials made in four repetitions and elaborated statistically.

Almost all agricultural important traits of rape are inherited as metric characters. Genetical variability and heritability are the data which allow to forecast breeding progress. Calculations were done for two different populations of winter rape both practically free of erucic acid. Obtained data are shown in table 1. These values refer to strain selection conducted on basis of mean values obtained in field trials made in four repetitions.

Investigation of correlations between traits can also give breeders very valuable informations about chances of further improvement of population.

Table 1: Genetic characteristics of two zeroerucic populations of winter rape

Trait	Mean	Range	Coefficient of variability	Heritability	Expected genetic gain (20 % selected)
I. population					
yield	15,4	7,3-23,6	22,4	0,57	2,7
oil content	41,7	39,3-43,1	1,9	0,81	0,89
% of plant which past through the winter	47,7	32,2-62,6	15,2	0,59	6,0
oxazolidine-thione	4,1	2,6- 8,3	28,2	0,94	1,52
butenyl-ITC	2,0	1,3- 3,6	22,4	0,92	0,58
pentenyl-ITC	0,9	0,3- 1,6	32,4	0,93	0,38
C 22 : 1	0,2	0,0- 0,8	11,1	0,00	0,0
C 20 : 1	1,5	1,2- 2,7	2,1	0,30	0,1
C 18 : 1	65,5	61,4-69,0	2,5	0,81	1,8
C 18 : 2	17,6	15,7-20,3	6,2	0,87	1,3
C 18 : 3	8,7	7,1-10,1	6,8	0,80	0,7
II. population					
yield	18,0	12,8-25,0	11,0	0,40	1,29
oil content	42,5	41,0-44,0	1,4	0,72	0,61
% of plant which past through the winter	77,4	65,3-85,1	28,7	0,00	0,00
oxazolidine-thione	5,1	4,0- 7,3	13,9	0,69	0,68
butenyl-ITC	2,7	2,0- 3,9	13,4	0,73	0,37
pentenyl-ITC	1,0	0,4- 1,7	36,0	0,82	0,41
C 22 : 1	0,1	0,0- 0,9	13,1	0,24	0,05
C 20 : 1	1,4	1,1- 2,0	10,2	0,05	0,1
C 18 : 1	63,0	61,1-65,7	2,0	0,82	1,4
C 18 : 2	20,2	18,6-21,7	3,2	0,42	0,9
C 18 : 3	9,4	7,9-10,8	8,5	0,84	0,7

Correlation coefficients between fatty acids calculated for one population practically zero erucic are shown in table 2. Low and insignificant correlation between linoleic and linolenic acid in examined population indicate that simultaneous selection for low linolenic and high linoleic acid content can be successful in this case.

Table 2: Correlations between fatty acids in zeroerucic population of winter rape

18 : 0	18 : 1	18 : 2	18 : 3	20 : 1	
-0,092	-0,256^{x}	-0,237^{x}	0,012	-0,190	16 : 0
	0,254^{x}	-0,354^{xx}	-0,282^{xx}	-0,076	18 : 0
		-0,809^{xx}	-0,429^{xx}	-0,578^{xx}	18 : 1
			-0,034	0,344^{xx}	18 : 2
				0,304^{xx}	18 : 3

x - statistically significant by P = 0,95
xx - statistically significant by P = 0,99

As a result of rape breeding work for better oil and meal quality two new varieties of winter rape are ready now in Poland.

These are:

1. Wipol (earlier K-712 or Wielkopolski) - low erucic (10-15 %) with lowered thioglucoside content;
2. K-2040 - practically zero erucic, normal in thioglucoside content;

The second one has good yielding ability and can be grown on 200 000 ha next year. Characteristics of new varieties and strains are given in tables 3 and 4.

Table 3: Characteristics of new varieties with improved chemical composition compared with characteristics of old varieties of winter rape

Variety or strain	Vegetation period (days)	Yield (relative values)	Oil content in seeds (% d.m.)	Erucic acid content (%)	Butenyl isothiocyanate content x	Pentenyl isothiocyanate content x	Oxazolidinethione content x
Old varieties							
Górczański			48				
Skrzeszowicki	303	100	46	50-55	3,5 - 5,0	0,5 - 1,0	9,5 - 13,0
New varieties							
Wipol	301	80	46	9-12	3,0 - 4,0	1,0 - 2,0	3,5 - 6,0
K - 2040	306	95	45	0- 1	3,0 - 4,5	0,5 - 1,0	8,5 - 10,5
New strains	300-310	80-100	38-48	0- 1	0,5 - 8,0	0,2 - 2,5	0,8 - 10,0

x - mg/g fat free dry matter

Table 4: Fatty acid composition of winter rape seed oil

	16 : 0	18 : 0	18 : 1	18 : 2	18 : 3	20 : 1	22 : 1
Skrzeszowicki	2.8	0.6	10.3	14,0	9.9	6.9	55.3
Górczański	2.7	0,7	12.2	12.8	9.4	7.7	54.5
Wipol	3.6	1.6	44.8	13.5	10.8	16.2	9.0
K - 2040	4.4	1.5	59.2	21.0	11.7	1.4	0.2
Sinus	3.7	1.1	40.0	19.9	11.8	7.4	15.4
INRA "0"	4.4	1.2	57.6	23.4	11.5	1.3	0.2

REFERENCES

1. BYCZYNSKA, B. & J. KRZYMANSKI (1968): Szybki sposób otrzymywania estrów metylowych kwasów tłuszczowych do analizy metoda chromatografii gazowej.
Tluszcze Jadalne 13, 108-114

2. BYCZYNSKA, B. (1974 a): Zmiennosć zawartosci tioglikozydów w nasionach rodzaju Brassica cz. I: "Metodyka analityczna"
Hodowla Roslin Aklimatyzacja i Nasiennictwo (in press)

3. BYCZYNSKA, B. (1974 b): Zmiennosć zawartosci tioglikozydów w nasionach rodzaju Brassica cz. II: "Badania kolekcji".
Hodowla Roslin Aklimatyzacja i Nasiennictwo (in press)

4. FINLAYSON, A. J., J. KRZYMANSKI & R. K. DOWNEY (1973): Comparison of Chemical and Agronomic Characteristics of two Brassica napus L. Cultivars, Bronowski and Target.
J. Am. Oil Chem. Soc. 10, 407-410

5. HARVEY, B. L. & R. K. DOWNEY (1964): The inheritance of erucic acid content in rapeseed (Brassica napus L.)
Can. J. Plant Sci. 44, 104-111

6. KONDRA, Z. P. & B. R. STEFANSSON (1965): Inheritance of erucic and eicosenoic acid content of rapeseed oil (Brassica napus L.).
Can. J. Genet. Cytol. 7, 505-510

7. KONDRA, Z. P. & B. R. STEFANSSON (1970): Inheritance of the major glucosinolates of rapeseed (Brassica napus) meal.
Can. J. Plant Sci. 50, 643-647

8. KRZYMANSKI, J. (1961): Ilosciowe oznaczanie wyzszych kwasów tluszczowych na chromatografie bibulowym przy pomocy soli miedzi.
Hodowla Roslin Aklimatyzacja i Nasiennictwo 5, 657-687

9. KRZYMANSKI, J. (1965 a): Modyfikacja metody ilosciowego oznaczania kwasów tluszczowych w olejach roslinnych za pomoca chromatografii bibulowej.
Hodowla Roslin Aklimatyzacja i Nasiennictwo 9, 423-429

10. KRZYMANSKI, J. (1965 b): Chromatograficzne oznaczanie ilosciowe kwasów tluszczowych wystepujacych w olejach rzepaków ozimych.
Hodowla Roslin Aklimatyzacja i Nasiennictwo 9, 531-548

11. KRZYMANSKI, J. (1966): Sklad olejów w nasionach krajowych roslin oleistych.
Hodowla Roslin Aklimatyzacja i Nasiennictwo 10, 535-546

12. KRZYMANSKI, J., A. PIOTROWSKA & B. SMOLSKA (1967): Badania nad dziedziczeniem sie zawartisci kwasu erukowego u mieszańców rzepaku jarego (Bronowski x Liho).
Biul. IHAR 6, 17-19

13. KRZYMANSKI, J. & R. K. DOWNEY (1969): Inheritance of fatty acid composition in winter forms of rapeseed Brassica napus.
Can. J. Plant Sci. 49, 313-319

14. KRZYMANSKI, J. (1970 a): Genetyczne możliwiści ulepszania skladu chemicznego nasion rzepaku ozimego.
Hodowla Roslin Aklimatyzacja i Nasiennictwo 14, 2, 95-133

15. KRZYMANSKI, J. (1970 b): Oznaczanie zawartosci tluszczów i wody w nasionach oleistych metoda NMR.
Tluszcze, Srodki Piorace i Kosmetyki 14, 4, 202-208

16. KRZYMANSKI, J. (1970 c): Inheritance of Thioglucoside content by rapeseed (Brassica napus).
J. Intern. sur le colza, Paris, 26-30. Mai 1970

17. STEFANSSON, B. R., F. W. HOUGEN & R. K. DOWNEY (1961): Note on the isolation of rape plants with seed oil free erucic acid.
Can. J. Plant Sci. 41, 218-219