Results of Breeding for Yellow-Seed in Turnip Rape and Rapeseed Varieties

E.B. BOCHKARYOVA, S.L. GORLOV & N.S. OSIK
VNIIMK, 17 Filatov St. Krasnodar 350038 Russia

Abstract

The use of inbreeding, interspecific hybridisation, X-ray seed irradiation and selection of individuals has allowed to develop the first yellow-seeded spring turnip rape "000" varieties Vostochnaya, Yantarnaya and Zolotistaya, and promising yellow-seeded forms of winter turnip rape as well as of spring rapeseed.

Introduction

Yellow-seeded forms of Brassica species (Brassica juncea Czern., Brassica campestris L.) are characterized by higher oil content due to considerably thinner seed coat than dark ones (1,2). It improves digestibility of meal and output of oil.
Worldwide yellow-seeded spring turnip rape varieties from Canada, Sweden, Finland and Russia are grown, and presently spring and winter B. juncea varieties are developed by Russian breeders. There are no analogous varieties of winter turnip rape and spring rapeseed; but studies on this problem are conducted in some countries. Rapeseed biotypes with yellow-brown and yellow seeds are developed in China, Czech Republic and Poland on the basis of the interspecific hybrids (3,4).
The purpose of this study was the development of yellow-seeded "000" turnip rape and rapeseed varieties using various breeding methods.

Materials and Methods

Interspecific hybridisation, selfing and selection of individuals were used to develop spring and winter yellow-seeded turnip rape varieties. The spring turnip rape sample VIR n-427773 comprised of black (60%) and yellow (40%) seeds was used as the initial material. The yellow-seed high erucic acid sample VIR k-3025 was used as winter hardiness donor for the development of the yellow-seed forms of winter turnip rape. The yellow-seed variety of spring turnip rape Candle from Canada was used as the source of low content of erucic acid.
For matching the flowering of winter and spring turnip rape the blossoming branches of the winter turnip rape were cut to cause second flowering. Reciprocal hybrids were obtained after castration of flowers and artificial pollination under bags according to the VNIIMK's method (5). Three hundred and ten flowers were emasculated in two breeding combinations.
Hybrid plants were grown in breeding nursery according to the scheme "female - F - male" in fall sowing (13-24.09.) in one row plots with 3 replications: 50x10 cm and 2 plants in the hole. The hybrid plants which were chosen for the seed colour and low erucic acid content were grown from F2 in space isolated plots in fall sowing: 50x25 cm one plant in the hole.
Analyses of fatty acid composition of the oil were performed by using gas-liquid chromatography (6), of the oil content by NMR analysis (7) and of glucosinolates by the palladium test (8). The winter hardiness was evaluated by counting the plants in autumn and spring. The black-seed collection sample VIR k-4984 and interspecific rape seed hybrid and Br. juncea Zem-1 (Australia) were used for the development of the yellow-seed forms of spring rape seed. The seeds of initial samples were created by y-rays (dose 100 kr) to obtain the constant yellow-seed forms.

Results and Discussion

Using inbreeding and repeated individual-family selection of the yellow-seed forms of spring turnip rape, the first variety " 000" Vostochnaya was developed in 1979-1985 in Russia.
The following research on the development of the yellow-seed spring turnip rape varieties was performed on the basis of the intervarieties hybrids and subsequent individual-family selection from the hybrid population. By 1989 the variety Yantarnaya (intervariety hybrid in combination variety Vostochnaya x line 946) was developed and by 1995 - the variety Zolotistaya (intervariety hybrid N 4401x929).
The competitive trials of the yellow and black-seed varieties of the spring turnip rape show (table 1) that the yellow-seed varieties are not inferior in seed yield to the black-seed variety Evvisa. The yellow-seed varieties have higher oil content (by 1.8-2.7%) and lower hull %. No difference was found in protein content between varieties.
The development of initial material of the yellow-seed winter turnip rape was initiated at VNIIMK in 1981.

Table 1: Characteristics of the spring turnip rape of VNIIMK selection. Krasnodar, 1993-1995

Variety	Seed colour	Yield (t/ha)	Oil content (%)	Protein (%)	Erucic (%)	Glucosinolates (mmol/g	(%)
Vostochnaya	yellow	11,9	45,5	24,2	0,8	28,0	15,0
Yantarnaya	yellow	13,3	46,0	24,6	0,3	22,6	15,0
Zolotistaya	yellow	13,9	46,4	24,5	0,2	20,0	16,0
Evvisa	black	12,5	43,7	24,0	3,2	38,0	19,5

Analysis of inheritance of the winter hardiness in the turnip rape interspecific hybrids in F1 has shown (Table 2) that in combinations where the mother is the spring turnip rape the winter hardiness trait is inherited intermediate. In the backcross combination, the F1 hybrid is close to the mother plant in winter hardiness.

Table 2: Overwintering of the winter and spring turnip rape hybrids. Krasnodar, 1982

Cross combination	Overwintering (%)
Winter turnip rape K-3025	100,0
K-3025 x Candle	95,0
Candle x K-3025	67,0
Spring turnip rape x K-3025	4,0

In F2, both hybrids had an average overwintering of 36,5%. The prosperities of some hybrid plants were differentiated in F2 according to its winter hardiness. Hybrid populations with 50-60% overwintering were selected both direct and in backcross with a level of this trait in k-3025 winter turnip rape of 68%.
The seed colour of the mother component (winter k-3025 turnip rape and Candle) was a mixture of yellow and black. The seeds of the F1 hybrids had a colour from dark yellow to brown. From 57 analysed F2 plants the yellow-seed plants

represented 21,1%, the plants with brown seeds represented 3,3% and black 75,4%.
Because of low seed set in turnip rape from self pollination selection of yellow-seed plants in the hybrid generation was performed after free pollination. The yellow-seed forms were obtained in F8. Besides the yellow colour of the seeds traits as oil and glucosinolates in seeds were controlled. As a result of the repeated individual selection yellow-seed breeding families (Table 3) have been developed with an oil content in the seeds of 44,9-49,0% and glucosinolates content in seeds of 16,1-24,4 mmol/g.

Table 3: Best selected families of winter turnip rape (" 000")

Family number	Oil (%)	Glucosinolates (mmol/g)	Erucic acid (%).
22086	44,9	18,8	0,2
22103	45,6	17,5	0,2
22120	46,0	21,1	0,1
22097	48,0	16,1	0,3
22108	48,4	18,6	0,9
22105	49,0	24,4	1,2
BH-213 (black seeds)	43,5	39,7	2,0

Best samples of yellow-seed winter turnip rape are included in the competitive trail.
First yellow-seed plants of the spring rape seed were obtained by X-ray radiation of J3-generation seeds from inconstant forms of the sample VIR k-4984 and from interspecific hybrid between rapeseed and B. juncea Zem-1 (9). As a result from following breeding procedures, promising samples of yellow-seed erucic acid free rape seed were developed which were characterised by high oil content and low glucosinolate content in the seeds (Table 4).

Table 4: Promising samples of yellow-seed spring rapeseed. Krasnodar, 1995

Sample	Days before flowering	Oil (%)	Glucosinolates (mmol/g)	Lodging (score 1-9)
25220	45	49,3	10,2	7,0
25124	44	51,9	12,8	7,0
25126	45	50,5	11,8	7,0
25230	44	50,5	11,9	6,0
25112	44	50,0	10,2	7,0
25229	45	50,4	9,6	7,0
25125	44	51,1	11,7	7,0
Shpat (black-seeded)	42	44,8	21,1	5,0

The development of yellow-seed rape seed has resulted in a significant decrease of the total content of glucosinolates in the seeds as compared to " 0" and " 00" varieties. The comparative studies were carried out during 2 yearsusing three groups of varieties of VNIIMK's origin with the purpose to evaluate the qualitative changes of rapeseed glucosinolate composition. Each group was comprising 4 samples with the following content of glucosinolates: 40-50; 20-30;10-15 mmol/g of seeds. The last group was represented by yellow seeds. The glucosinolates were analysed using highly effective liquid chromatography (HPLC)according to the EEC standard method. The results of analyses have shown that the glucosinolate composition of the seeds from different variety types was the same (Table 5), although there were significant quantitative differences. The progoitrine predominated in the group of alkenylglucosinolates in all varieties. The content of gluconapin was double less, there was a small quantity of glucobrassicanapin and napoleiferin. The 4-hydroxyglucobrassicin was more than 95% of the total indolglucosinolates in the seeds.
It should be noted that in all types of varieties the indolglucosinolates quantity was at the same level (7,12-7,33 mmol/g of seeds) and its percentage was 16,0-30,0% in " 0" and " 00" varieties and more than 50% in the " 000" varieties.

Evidently, breeding for decrease of glucosinolate level in the seeds was carried out at the expense of alkenylglucosinolates, and indolglucosinolates may be reserve in the further breeding.

Table 5: Glucosinolate composition of different spring rape seed varieties (µmol/g) Krasnodar, 1994–1995

Glucosinolate	Type of variety		
	"0"	"00"	"000"
Alkenyl			
Gluconapin	11,30	4,19	1,53
Glucobrassicanapin	4,33	0,81	0,59
Progoitrin	19,12	8,82	3,21
Napoleiferin	0,80	0,23	0,12
Indol			
Glucobrassicin	0,21	0,30	0,26
4-OH-glucobrassicin	7,12	6,82	6,94
Other			
Glucoalyssin	1,61	0,79	0,43
Gluconasturtiin	1,19	0,01	0,01
Total of alkenyl	35,55	14,77	5,45
Total of indol	7,33	7,12	7,20
Total	45,68	22,69	13,09

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