Progress in breeding research on double low white mustard (*Sinapis alba* L.)

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Abstract

White mustard is a spring oil plant whose importance has been increasing in Poland recently due to its multiple applications: for seeds, as a catch crop, phytosanitary plant and also as a melliferous plant. Seed yield of white mustard is more stable and less dependent on climate and environment conditions than the yield of spring rapeseeds. In Polish climatic conditions frosty winters may cause significant losses on winter rapeseed plantations. Therefore a spring plant is needed to replace lost winter rapeseed plantations. White mustard may become such a plant after the improvement of its chemical composition. The research conducted so far resulted in obtaining genotypes of white mustard characterised by low content of erucic acid and low content of glucosinolates and without sinalbin. High variability coefficients for examined glucosinolates indicate the possibility of further progress in selection for lower content of these compounds.

Key words: white mustard, yellow mustard, erucic acid, glucosinolates, drought resistance, *Sinapis alba* syn. *Brassica hirta*.

Introduction

The basic oil plant in Poland is winter rapeseed. However, in Polish climatic conditions frosty winters may cause significant losses on winter rapeseed plantations. A spring oil seed plant is needed to replace winter rapeseed in case of major winter losses. Usually spring rapeseed is used for this purpose. Spring rapeseed is yielding very variable due to its sensitivity to drought. White mustard may be better spring oil-protein plant after the improvement of its chemical composition. Among cruciferous plants, it is most resistant to the deficiency in precipitation during vegetation period, which occur very often in our country (Dembinski 1975). Investigations by Musnicki et al. (1997) show that white mustard is a plant most constantly yielding among all spring oil plants.

The seeds of white mustard are yellow and have reduced content of fiber as compare with rapeseed (Ochodzki, Piotrowska 1997). They are rich in protein with good aminoacid composition (Krzymanski at al.1991); Slominski et al. 1999). Varieties cultivated up to now (table 1) contain erucic acid in seed oil and glucosinolates, which remain in meal after oil extraction (Dembinski 1975; Krzymanski 1966; Krzymanski et al. 1990, 1991.

White mustard may become an alternative, oil-protein crop sown in spring. To achieve this target white mustard should be improved through the breeding of new double low varieties without erucic acid and very low in glucosinolate content (Krzymanski et al. 1990, 1991; Pietka et al. 1998, 2004; Raney et al. 1999; Katepa-Mupondwa et al. 1999; Slominski et al. 1999).

The first step in improving white mustard was achieved - Polish zero erucic white mustard variety Bamberka was licensed last year. Its chemical characteristic is given in table1.

Materials and methods

White mustard population used in research and breeding was obtained through crossings of 15 Polish and foreign varieties. This population was selected during many years. An individual plant selection or half seed selection was applied. The 1st stage of research resulted in low glucosinolate and low erucic lines (Krzymanski et al. 1991). These lines were crossed to initiate population of hybrids for breeding new double improved lines of white mustard (Pietka et al. 1998, 2004). The selection was conducted for lower erucic acid and glucosinolate content, and especially sinalbin – the main glucosinolate of white mustard seeds.

Genotypes without erucic acid were obtained through:
- individual plant selection with the use of two plants sib mating
- individual selection of plants obtained from half seed analysis

The seed was swollen and outer cotyledon was removed for chemical analysis and second cotyledon with germ was used for plant growing and production the seed of next generation.

Selection for genotypes with lower glucosinolates content was carried out using the following methods:
- selection of progenies from single plants obtained by free pollination,
- selection of progenies from plants produced by two plants sib mating,
- individual selection of plants from selfpollination at bud stage (method is described by Brown et al. 1999)
- individual plant selection on the basis of chemical analyses of seeds from first siliques and then cross pollination among

still flowering selected plants

The last method was proved to be the most efficient.

The composition of fatty acids were determined by gas chromatography of methyl esters (Byczynska, Krzymanski 1969). Glucosinolate content and composition were determined by gas chromatography of sillyl derivatives of desulphoglucosinolates (Michalski et al. 1995).

Results and discussion

Fatty acid composition in seed oil from new zero erucic Bamberka variety is compared with fatty acid composition in seed oils of traditional varieties Nakielska and Borowska varieties (Table 1).

Table 1.Chemical seed composition of two Polish varieties of white mustard (*Sinapis alba* L.)

Trait	Borowska	Nakielska	Bamberka
Oil content [%]	25.6	26.5	28.1
Fatty acids:			
$C_{16:0}$ - palmitic acid	2.8	2.6	3.8
$C_{18:0}$ - stearic acid	0.9	1.1	2.5
$C_{18:1}$ - oleic acid	22.5	29.5	65.5
$C_{18:2}$ - linoleic acid	11.8	9.7	10.6
$C_{18:3}$ - linolenic acid	8.5	9.9	15.5
$C_{20:1}$ - eicosenoic acid	9.7	11.6	1.8
$C_{22:1}$ - erucic acid	43.8	35.7	0.3
Glucosinolates:			
sinigrin	0.0	0.0	1.0
sinalbin	143.0	151.0	148.0
gluconapin	0.0	0.2	0.0
gluco*brassica*napin	0.0	0.1	0.0
progoitrin	2.1	1.3	1.9
napoleiferin	0.0	0.0	0.2
brasscin	0.2	0.3	0.3
4-hydroxybrassicin	0.0	0.0	0.8
Total of glucosinolates	145.3	152.9	150.3
Total of aliphatic glucosinolates	2.1	1.6	2.4

561lines of white mustard from research project were analysed on fatty acid composition in seed oil and on glucosinolate content in seeds. This generation was still segregating according these traits characterised by in seeds. Variability estimated for contents of erucic acid and glucosinolates is presented in table 2. The content of erucic acid in investigated lines ranged from 0.0-13.3% with high variability coefficient 120.1%. It points out to the possibilities of further selection for the content of this component.

Also the high coefficients of variability for the contents of individual glucosinolates: gluconapin, progoitrin, 4-hydroxybrassicin, sinalbin and for total of alkenyl glucosinolates and total of all glucosinolates, confirmed the differenciated nature of the investigated population of white mustard in respect to these characteristics. A very high coefficient for the content of sinalbin indicates the larger number of lines with the lowest and zero content of this component.

On the basis of chemical analysis 46 lines were chosen for further research and breeding works. These lines compared to initial population are shown in table 2. Chosen lines are free from sinalbin – the main glucosinolate of white mustard. High coefficients of variability for the remaining examined characteristics show the possibility of progress in further decreasing the content of these harmful components.

Coefficients of correlation among examined traits were calculated for both populations before and after selection. Large number of lines before selection allowed for determining even weaker correlation's as statistically significant at the level of α=0.01 (Tab.3).

All investigated glucosinolates (apart from sinalbin) are positively correlated. High correlation was stated for progoitrin and total of alkenyl glucosinolates, and the sum of all glucosinolates. It can be expected because progoitrin is the main component of alkenyl glucosinolates and the sum of all glucosinolates. Lower but also highly significant correlations were stated between the content of 4-hydroxybrassicin and the sum of all glucosinolates. The content of sinalbin is negatively, non-significantly correlated with progoitrin, the sum of alkenyl glucosinolates, 4-hydroxybrassicin and sum of all glucosinolates.

Similar co-variability's occurred between investigated glucosinolates for lines for further studies. The selection in still segregating population is continued with the aim to obtain new lines with lower values for the examined traits.

Larger variability of morphological traits of white mustard seeds was obtained through chemical and physical mutagenesis (Olejniczak, Adamska 1999). Olsson (1960) obtained dwarf forms of white mustard using×rays. Mutagenesis appeared to be less effective than methods which we used in respect of white mustard variability.

Table 2. Characteristics of investigated lines of white mustard

Parameters	Erucic acid		Progoitrin		Total of aliphatic glucosinolates		4-hydroxybrassicin		Sinalbin		Total of glucosinolates	
	A	B	A	B	A	B	A	B	A	B	A	B
Number of lines	561	46	561	46	561	46	561	46	561	46	561	46
Mean	1.6	0.2	16.1	11.5	18.1	13.2	4.5	3.8	0.1	0.0	25.0	20.2
Standard deviation	1.9	0.3	6.1	3.2	6.3	3.4	2.1	1.4	0.5	0.0	7.3	4.3
Minimum	0	0	0	5.2	2.1	6.2	0	1.1	0	0.0	2.4	9.0
Maximum	13.3	0.7	40.2	20.7	42.7	23.2	15.0	8.3	9.7	0.0	53.2	31.2
Coefficient of variability	120.1	121.6	37.8	27.6	34.4	25.5	47.3	36.0	781.0	–	29.6	21.5

A - all lines B - selected lines

Table 3. Correlation coefficients for glucosinolate contents in lines of white mustard.

Under diagonal all lines (n=561) above diagonal chosen lines (n=46)

Trait	Progoitrin	Total of aliphatic glicosinolates	4-hydroxybrassicin	Sinalbin	Total of glucosinolates
Progoitrin	1	0.993**	0.090	-	0.825**
Total of aliphatic glicosinolates	0.968**	1	0.061	-	0.809**
4-hydroxybrassicin	0.132**	0.109	1	-	0.486**
Sinalbin	–0.018	–0.003	–0.045	1	-
Total of glucosinolates	0.874**	0.892**	0.484**	–0.026	1

* - significant at level $\alpha = 0{,}05$ ** - significant at level $\alpha = 0{,}01$

Conclusions

Genotypes of white mustard characterised by significantly lowered content of erucic acid and glucosinolates and by zero content of sinalbin were obtained.

Substantial progress was made on the way to double improved white mustard as an alternative to spring oilseed rape. Double low varieties of white mustard as oil-protein crop can be good alternative in the area where conditions of drought period during growing period is frequent.

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