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Full Length Research Paper

Brassica oleracea **genotypes displaying interesting fatty acid profiles for** ***Brassica napus*** **breeding**

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Brassica oleracea **(CC) normally displays an erucic acid (22:1) content ranging from 28 to 63%. In the course of studies dealing with the inheritance of erucic acid content in the seed oil of** ***Brassica*** **species individual plants belonging to three accessions of** ***B. oleracea conv.*** **c*apitata*** **- Kashirka 202, Ladozhskaya DS 8395 and Eisenkopf - were identified displaying low, intermediary and high erucic acid content. The fatty acid profiles of these cabage genotypes and their potential use in** ***Brassica napus*** **breeding is discussed.**

Key words: *Brassica oleracea*, cabbage, low-erucic acid mutant, fatty acid composition, breeding.

INTRODUCTION

Rapeseed and mustards derived from several locally distributed members of the genus *Brassica* have become one of the worldwide most important sources of vegetable oil due to substantial progress in breeding and cultivation practice. Especially *Brassica napus* displaying ‘double-low‘ seed quality (low erucic acid, low glycosinolate content) dominates field crop production in several European countries with cool-temperate climates. Efforts to develop low erucic character in several *Brassica* species led to the discovery of low-erucic acid mutants in the species *Brassica rapa* (AA) (Downey, 1964), *B. napus* (AACC) (Stefansson et al., 1961; Stefansson and Hougen, 1994) and *Brassica juncea* (AABB) (Kirk and Oram, 1978). In amphidiploid *B. carinata* (BBCC) low-erucic acid mutants were not known up to the 90´s. Different strategies, such as the selection of transgressive segregants in the crossing progeny of diverse *B. carinata* accessions (Alonso et al., 1991), induced mutations and interspecific crosses with low-erucic *B. napus* and *B. juncea* (Getinet, 1987; Fernandez-Escobar et al., 1988) were used to reduce the erucic acid content. With the first and last mentioned method low erucic acid forms were selected successfully (Alonso et al., 1991; Getinet et al., 1994). For the other monogenomic species *Brassica oleracea* (CC) and *B. nigra* (BB) low-erucic acid forms were not cited in the literature up to now (Downey, 1964; Stefansson et al., 1961; Stefansson and Hougen, 1994).

In the course of studies dealing with the inheritance of erucic acid content in the seed oil of *Brassica* species, cabbage genotypes displaying low erucic character were identified. Individual plants belonging to the three *B. oleracea* accessions, namely Kashirka 202 and Ladozhskaya and Eisenkopf, were identified being very low in erucic acid content. The fact that all these genotypes display low erucic acid content and that a monogemic inheritance was detected in Kashirka were published before (Lühs et al., 2000; Seyis et al., 2004). During the mentioned studies dealing with the genetics of erucic acid content individual half seed plants with intermediary and high erucic acid were also determined besides these half seed plants displaying low erucic acid content. Between the well known six Brassica species, oilseed rape (*Brassica napus* L.) is the most important agricultural crop plant. Rapeseed is an interspecific amphidiploid hybrid between two unknown parents from the diploid species *B. rapa* and *B. oleracea*. But the genetic variation in the present gene pool of *B. napus* is rather limited. The reason for this limited trait variation found within the *B. napus* genetic resources available for breeding is the result of oilseed rape’s relatively recent origin from only two parents and from the intensively quality breeding of this plant in the last decades.

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Interspecific hybridization has great potential for the improvement of Brassica crops (Inomata, 1997) as it creates genetic variation (Prakash, 1973; Choudhary, 1997) and is a valuable tool for transferring traits from one species to another (Prakash and Chopra, 1988; Raney et al., 1995a, b). Therefore, one way of increasing trait variation is the development of so called resynthesised rapeseed forms using the diploid progenitors.

The aim of modern plant breeders are to develop higher yielding, nutritious and environmentally friendly varieties that improve our quality of life without harnessing additional natural habitats to agricultural production (Zamir, 2001). Without a broad base of heterogeneous plant material, it is impossible for plant breeders to produce cultivars that meet the changing needs regarding adaptation to growing conditions, resistance to biotic and abiotic stresses, higher product yield or specific quality requirements (Friedt et al., 2007). Therefore, the most efficient way to improve the performance of crop varieties further is to have access to a large diverse pool of genetic diversity. Especially, interspecific hybridizations are a useful tool for the broadening of genepools. Considering, that *B. napus* is an amphidiploid plant and that the genetic diversity in B*. oleracea* is very rich, the use of resynthesised rapeseed forms will broaden the present narrow genetic basis in the *B. napus* gene pool.

Especially the development and selection of resynthesised rapeseed genotypes displaying low erucic acid character is important, because the low erucic character present in the gene pool of *B. napus* has an intraspecific origin. Canadian plant breeders were identified plants with low eicosenoic acid and erucic acid content (Downey and Harvey, 1963; Stefansson et al., 1961) in spring rapeseed cultivars. The potential use of *B. oleracea* genotypes, described regarding their fatty acid composition, in *B. napus* breeding is discussed.

MATERIALS AND METHODS

Plant matarial

Seed material was taken from the USDA-ARS Plant Genetic Resources Unit, Cornell University, Geneva, New York, USA.

Methods

The preparation of half seeds of the genotypes Kashirka and Ladozhskaya and Eisenkopf was done according to the method described by Lühs (1996) and Thies (1971).

RESULTS

During these experiment half seed plants displaying different erucic acid contents would be determined and these half seed plants were divided regarding their fatty acid acid composition in three groups (Table 1). These groups are respectively the low erucic acid group (0 - 3% erucic acid), the intermediary group (13 - 39%) and the high erucic acid group (>40% erucic acid). The numbers of investigated half-seed plants for every genotype in group are given in brackets (Table 1). In the zero erucic acid groups, the amount for every fatty acid seem to be very similar for all genotypes regarding mean values (Table 1).

The highest oleic acid content was determined in Kashirka (57,46%), followed by Eisenkopf (56,51%) and Ladozshkaya (55,35%). Correspondingly, the erucic acid content of all genetypes was low. In the intermediary group Kashirka and Eisenkopf showed higher amounts of erucic acid (C22:1) compared with Ladozhskaya, respectively 28,74% and 30,43 %. Ladozhskaya display higher amounts of oleic acid (29,26%), but lower amounts of erucic acid (18, 8%). In the high erucic acid group, Ladozhskaya and Eisenkopf showed higher erucic acid contents (both 45,1%), followed by Kashirka (42,7%).

DISCUSSION

Contrary to oilseed rape and turnip rape (Lühs et al., 2000; Jönsson, 1977; Anand and Downey, 1981; Chen and Heneen, 1989; Lühs and Friedt, 1995a) studies regarding fatty acid composition of *B. oleracea* (CC) seed oil are lacking (Lühs et al., 2000). This rather neglected *Brassica* species displays normally a high erucic acid (C22:1) content ranging between 28 - 63% (Lühs and Friedt, 1995b). Previous studies indicated an additive mode of inheritance in some *Brassicaceae* species including *B. rapa* (Dorrell and Downey, 1964), *B. napus* (Harvey and Downey, 1964; Chen and Heneen, 1989; Lühs and Friedt, 1995a), *B. juncea* (Kirk and Hurlstone, 1983), *B. carinata* (Getinet et al., 1994) and *Sinapis alba* (Raney et al., 1995).

In a mentioned previous study after applying half-seed selection, the subsequent analysis of the progeny might confirm whether erucic acid content is determined by one gene locus as one could expect (Lühs et al., 2000). So, it could be detected that the genotype Kashirka displays a monogenic inheritance regarding erucic acid content. Due to the different erucic acid distribution seen in Ladozhskaya in the intermediary group it cannot be said that there is a monogenic inheritance, but this needs further detailed investigation.

The discovery, that *B. napus* is an interspecific hybrid (resynthesised rapeseed = RS rapeseed) of the cross between the diploid *Brassica* species *B. oleracea* and *B. rapa* (Morinaga, 1934; U, 1935) and the determination that resynthesised rapeseed forms are representing genetically a new genepool compared with present breeding material (Song et al., 1993; Seyis et al., 2003a; Voss et al., 1998; Becker et al., 1995), give reason for the idea to use resynthesised rapeseed forms in producing either semi-synthetic hybrids through crossing with

Table 1. Fatty acid composition in mean values of investigated individual *Brassica oleracea* plants (number of analyzed plants are given in brackets).

Genotype		C16:0	C18:0	C18:1	C18:2	C18:3	C20:1	C22:1	C24:1
Zero erucic acid type	Kashirka (n = 24)	3.58	0.94	57.46	22.07	12.93	1.90	0.21	0.28
	Min-Max.-Values	3-1-4.4	0.2 - 1.3	53.2 - 63.4	17.7 - 26.5	11.2 - 15.6	1.5 - 2.5	0 - 0.6	0.1- 0.6
	Standart Deviation	0.37	0.22	2.85	2.42	1.3	0.25	0.19	0.13
	Ladozshkaya (n = 25)	3.92	1.09	55.35	21.24	14.56	2.81	0.62	0.32
	Min-Max.-Values	3.1 - 4.8	0.7-2.1	38.9 - 65.5	16.0 - 24.7	11.3 - 23.0	0 - 8.5	0 - 2.4	0-0.9
	Standart Deviation	0.5	0.3	6.8	4.2	2.9	2.7	0.7	0.2
	Eisenkopf (n = 20)	5.84	1.09	56.51	23.63	11.48	1.76	0.36	0.30
	Min-Max.-Values	4.4 -7.5	0.7-1.4	46.5 - 65.5	15.0 - 32.1	8.1 - 14.4	0.4 - 5.0	0 - 1.2	0.1- 0.7
	Standart Deviation	0.8	0.2	5.9	5.9	1.5	1.0	0.4	0.2
Intermediary type	Kashirka (n = 21)	2.97	0.88	24.77	13.96	11.23	15.78	28.74	0.68
	Min-Max.-Values	2.6 - 3.7	0.6-1.2	21.5 - 28.9	10.5 - 17.2	9.5-14.4	12.9 - 21.0	20.8 - 34.8	0.4 - 1.4
	Standart Deviation	0.3	0.1	2.2	1.7	1.2	2.1	3.9	0.3
	Ladozshkaya (n = 33)	3.40	0.89	29.26	15.78	11.76	12.11	24.56	1.24
	Min-Max.-Values	2.6 - 4.4	0.6 - 1.4	18.5 - 39.3	9.0-21.9	8.2-17.3	8.6 - 16.4	13.3 - 38.3	0.1 - 2.3
	Standart Deviation	0.5	0.3	1.7	2.7	2.1	2.5	**9.5**	0.6
	Eisenkopf (n = 33)	4.48	0.96	23.38	15.41	9.64	12.95	30.43	1.41
	Min-Max.-Values	2.5 - 6.9	0.6 - 1.6	14.4 - 30.8	10.3-22.2	0.00-17.0	10.3 - 16.4	23.4-39.6	0.4 - 2.7
	Standart Deviation	1.0	0.2	4.0	3.2	2.8	1.6	4.5	0.5
High erucic acid type	Kashirka (n = 3)	2.90	0.67	19.23	10.43	9.53	12.03	42.70	1.05
	Min-Max.-Values	2.4 - 3.2	0.6 - 0.8	18.3 - 20.7	9.50-12.2	8.5 - 10.8	10.1-14.8	40.4 - 47.2	0.5 -1.2
	Standart Deviation	0.44	0.2	1.29	1.53	1.17	2.46	3.9	0.35
	Ladozshkaya (n = 12)	2.77	0.67	15.93	12.51	10.58	9.90	45.1	1.31
	Min-Max.-Values	2.0 - 3.6	0.6 - 0.8	12.1-19.4	9.0 - 14.2	7.6 - 13.5	7.9 - 11.6	36.3 - 52.5	0.6 - 1.9
	Standart Deviation	0.49	0.1	2.94	1.55	1.82	1.44	4.16	0.41
	Eisenkopf (n = 22)	3.41	0.90	15.2	12.4	9.5	10.10	45.1	1.5
	Min-Max.-Values	2.0 - 6.5	0.62 - 1.2	12.4 - 19.1	8.9 - 21.7	6.6 - 13.3	7.7 - 12.5	40.3 - 52.2	1.0 - 2.6
	Standart Deviation	1.12	0.19	1.9	3.4	1.86	1.38	2.82	0.5

conventional material or in developing true hybrids through crossing with msl-lines (msl = Männliche Sterilität Lembke) (Seyis et al., 2001; Seyis et al., 2003b ; Lühs et al., 2003). For this purpose low erucic acid mutants of *B. oleracea* were crossed with double low *B. rapa* forms to develop resynthetic rapeseed with low erucic acid content (Lühs et al., 2003; Seyis et al., 2005). Success in removal of erucic acid led many plant breeders to look at other possible modifications in rapeseed. One of the first objectives to increase the level of erucic acid in order to increase the value of oil used for the industrial production of chemicals (Latta, 1990; Sonntag, 1991; Lühs, 1996). Several strategies have been developed (Taylor et al.,

1992) but there has been no reports of cultivars with erucic acid levels (HEAR) greater than 55% to date. Beside HEAR and LEAR (Low erucic acid rapeseed) several other fatty acid modification types have been reported in the literature, but do not seem to be under commercial production – these include types with high or low levels of saturated fatty acids (Persson, 1985; Friedt and Lühs, 1998; Thelen and Ohlrogge, 2002) as well as alcolohols and waxes (Anonymous., 2003). Some of the delay in producing commercialized varieties of these types has been the general resistance towards the acceptance of genetifically modified oils (Ratnayake and Daun, 2002).

The three investigated *B. oleracea* accessions display interesting fatty acid profiles. With the use of these genotypes in interspecific crosses with different quality type *B. rapa* forms it will be possible to create intersprecific rapeseed forms with different fatty acid compositions, which are different from present rapeseed genetic material, without using genetic transformation. Further, the mentioned comparatively narrow genetic basis in rapeseed could be increased with the use of the both highly polymorphic diploid parents, what offer a much broader genetic variability that then can be exploited. In general, the low yield performance and conventional quality (high erucic acid-high glucosinolates rapeseed, HEAR) of resynthesised *B. napus* is a handicap for the broad use of this novel genepool in modern rapeseed breeding programmes. However, with the use of low erucic acid mutants among *B. oleracea* accessions and the development of synthetic rapeseed through wide crosses with respective 0- or 00-quality *B. rapa* genotypes will offer the possibility to use this basic material as a genetic resource for quality and yield improvement in oilseed rape breeding.

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