Investigation of F_1, F_2 and F_3 hybrid performance in winter oilseed rape (*B. napus* L.)

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ABSTRACT

Successful hybrid seed production requires identification of good combiners and a male sterility. The purpose of this study was to investigate heterosis for yield in winter oilseed rape, examine its genetic basis and observe morphological characters, which may influence yield. Field trials were conducted with F_1 - F_3 progenies in 1999, 2000 and 2001 at the Experimental Station Dłoń that belongs to the Agricultural University of Poznań. Plots, 10 m^2 in size, were arranged in a randomised complete block design with three replicates. The hybrid material originated from diallel crosses of three Polish cultivars of winter oilseed rape and two own MS lines.
The observed items showed lower values such traits as fertility, number of seeds in siliqua, length of siliqua and 1000 seed weight at self-pollination compare to cross-pollination. In all cases, excluding one (hybrid obtained on the base of MS line B) hybrids yielded significantly better compare to initial forms.

Key words: heterosis, resynthesized lines, hybrid, male sterility

INTRODUCTION

There has been considerable interest in the development of hybrid oilseed rape (*B. napus*) cultivars since the discovery male sterility (MS) (Thompson 1972) or self-incompatibility (SI) (Thompson 1979). The next steps towards the development of oilseed rape cultivars was the reporting of significant levels of heterosis for yield in hybrids derived from crosses of rapeseed (Bartkowiak-Broda et al. 1995).

In recent years, there have been many reports of heterosis in oilseed rape. Commercial exploitation of this potential depends on the development of systems that allows the production of seed at competitive price relative to yield advantage. At present, oilseed rape hybrids are produced by applying different sources of pollen controlling systems (SI, MS), between them MS lines originating from artificially resynthesized oilseed rape (Wojciechowski 1993). In some cases hybrids between conventional cultivars outyielded crosses with resynthesized oilseed rape (Kräling 1987). The aim of the following studies was to examine the genetic value of MS lines resynthesized at our Department in comparision with hybrid material originating from diallel crosses of conventional cultivars.

MATERIALS AND METHODS

The experimental material comprised of 6 F1, F2 and F3 progenies derived from diallel crosses of 3 Polish cultivars (Leo, Mar, Mah 789) of winter oilseed rape, 2 progenies derived through crossing two own MS lines with winter oilseed rape and 3 initial cultivars used in diallel crosses. Field trials were conducted in 1999-2001 at the Experimental Station Dłoń that belongs to the A. Cieszkowski Agricultural University of Poznań. Plots 10 m^2 in size, were arranged in a randomised complete block design with three replicates. Data were recorded on single plants for height, number of branches, number of siliqua and seed/plant, siliqua length, seed yield/plant, 1000-seed weight (those data are not presented in this paper) and fertility expressed by percentage ratio of settled siliqua/pollinated flowers, percentage of fertilized ovules and mean number of seed/siliqua at self- and cross-pollination. Heterosis effect was studied for seed yield and statistical analyses were made by using Duncan's test.

RESULTS

In all observed F_1-F_3 hybrid progenies and initial cultivars there were observed lower values such traits as fertility, number of seed/siliqua (table 1), length of siliqua and 1000-seed weight at self-pollination compare to cross-pollination. After self-pollination the fertility in F_1 was from 18,1-51,1 % lower than after cross-pollination and from 22,1-55,1 % and 19,2-47,0 % in F_2 and F_3, respectively. Mean number of seed/siliqua varied strongly and ranged from 7,9-15,6 in F_1-F_3 at self-pollination and from 11,1-24,4 at cross-pollination. Percentage of fertilized ovules in both hybrids and cultivars was higher at cross-pollination than at self-pollination and in F_1 it ranged from 42,5-67,1 % and 25,6-46,9 %, respectively. In F_2 and F_3 at cross-pollination it ranged from 46,3-62,1 % and from 41,6-71,2 %, respectively and from 24,7-39,6 % and 26,1-44,5% at self-pollination.

Comparing the seed yield of hybrids from diallel crosses, hybrids derived through crossing with resynthesized MS lines and initial cultivars an average seed yield in almost all hybrid progenies, excluding one (progeny derived through crossing MS line B with fertile oilseed rape genotypes) was higher compare to initial forms (table 2). In F_1 the hybrid Leo x Mar yielded the best (38,7 dt/ha). The hybrid MS (A) showed a little lower seed yield (37,4 dt/ha) but difference was not significant. In F_2 and F_3 progenies the best seed yields were obtained from the hybrid MS (A), 41,9 dt/ha and 36,2 dt/ha, respectively. It is noticeable that second hybrid derived through crossing MS line B with oilseed rape gave the lowest seed yield compare to both other hybrids and parental cultivars.

DISCUSSION

The observations concerning studied traits showed that they were markedly affected by the way of pollination. It was found that after self-pollination, values such traits as fertility, number of seeds per siliqua, siliqua length and 1000-seed weight were lower than after cross-pollination in all progenies. Similar results have been reported by Mackiewicz et al. (1979) in different cultivars and strains of winter oilseed rape.

In the present study, it was observed that seed yield of F_1-F_3 hybrids in general exceed the yield of mid-parent. Only in the case of the hybrid MS (B) the seed yield was lower compare to parental forms. Oposite to this, the hybrid MS (A) gave the highest seed yield. According to Ali et al. (1995) heterosis measured as the superiority of hybrids over their mid-parent, is proportional to the genetic distance between their respective parents. In this study MS lines were derived from interspecific crosses (*B. oleracea x B. campestris)* (Wojciechowski 1993) and genetic distance between them and used cultivars was higher than between particular cultivars. However, two hybrids derived through crossing MS lines A and B with oilseed rape cultivar yielded quite differently. So, it means that heterosis depends not only from the genetic distance but also from specific combining ability (SCA).

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Table 1. Fertility and mean number of seeds per siliqua and percentage of fertilized ovules after self- and crosss-pollination of F_1, F_2, F_3 hybrids and parental forms of winter oilseed rape

Item	Fertility (%)			Mean number of seeds/siliqua			Percentage of fertilized ovules		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Hybrids				Self-pollination					
Leo x Mar	43.0	28.6	59.3	7.9	8.4	13.6	25.6	27.8	26.1
Leo x Mah 789	31.2	21.6	52.8	13.3	8.1	12.4	44.9	32.5	34.7
Mar x Leo	46.4	53.1	38.1	13.2	9.2	11.4	39.6	31.7	38.2
Mar x Mah 789	42.1	52.3	27.0	11.0	11.2	9.5	33.3	34.6	34.1
Mah 789 x Mar	47.3	35.1	49.8	15.6	11.0	11.7	46.6	39.6	44.5
Mah 789 x Leo	34.5	45.9	30.6	10.3	7.3	14.6	33.6	24.7	29.7
MS (A)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MS (B)	0,0	0.0	0.0	0,0	0.0	0.0	0.0	0.0	0.0
Mean of 3 parental forms	39.2	21.8	21.4	9.0	6.2	7.6	28.7	21.8	22.3
LSD (α =0,05)	3.0	6.8	7.2	1.4	0.9	1.2	4.0	3.0	3.7
				Cross-pollination					
Hybrids									
Leo x Mar	74.2	73.4	78.5	20.0	17.7	15.7	64.7	58.6	63.6
Leo x Mah 789	72.3	76.7	83.5	20.0	17.1	16.9	67.6	58.2	62.3
Mar x Leo	64.0	82.8	72.0	21.1	18.0	17.3	63.4	62.1	67.2
Mar x Mah 789	82.5	74.4	74.3	21.1	15.0	16.6	63.9	46.3	58.7
Mah 789 x Mar	84.3	72.4	86.3	24.4	16.8	15.7	66.9	60.4	61.1
Mah 789 x Leo	68.6	73.0	71.7	20.6	17.7	18.4	67.1	59.8	71.2
MS (A)	84.8	71.7	82.1	14.9	17.2	19.8	50.5	51.5	53.0
MS (B)	55.4	68.3	58.6	13,4	15.2	11.1	42.5	50.0	41.6
Mean of 3 parental forms	75.1	69.4	75.7	21.0	15.0	15.9	67.0	52.6	61.1
LSD (α =0,05)	4.9	2.1	4.1	1.7	0.6	1.2	4.4	2.8	4.3

Table 2. Yield of seeds per ha of F_1, F_2, F_3 hybrids and parental forms of winter oilseed rape

Item	Seed yield [dt/ha]			Significance at:*					
				α = 0,01			α = 0,05		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Hybrids									
Leo x Mar	38.7	34.7	27.6	a	abc	a	a	abc	a
Leo x Mah 789	36.8	37.6	30.9	ab	bc	b	b	bc	b
Mar x Leo	34.0	35.0	30.2	c	abc	ab	c	abc	b
Mar x Mah 789	33.9	36.5	30.6	cd	abc	ab	cd	abc	b
Mah 789 x Mar	33.2	33.5	31.7	cde	abcd	b	cd	a	b
Mah 789 x Leo	35.3	33.7	28.4	bcdef	abcd	b	bcd	ab	a
MS (A)	37.4	41.9	36.2	abf			ab	d	
MS (B)	24.1	31.3	25.9	g	abcd	a	g	a	a
Mean of 3 parental forms	27.1	33.2	26.0	g	d	a	g	a	a

*/ The same letter at the items means that differences are not significant (Duncan's test)