A BRASSICA STUDY OF RAPESEED (Brassica napus) F1 HYBRIDS, FROM LINES OF SAME AND DIFFERENT GEOGRAPHIC ORIGINS

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INTRODUCTION

The occurence of heterosis in rapeseed (Brassica napus) has been demonstrated by numerous authors (Schuster, 1969 ; Schelkudenko, 1968, 1972 ; Schuster and Mickael, 1976 ; Shiga, 1976 ; Lefort-Buson, and Dattée, 1982a, 1985a, Sernyk, 1983 ; Grant and Beverdorsf, 1985). In some cases it appeared that crosses between lines of very different geographic origins overyielded crosses between lines of neighbouring geographic origins. For example, crosses between European and Asiatic lines overyielded Asiatic F1 hybrids in Japan (Shiga, 1976) and European F1 hybrids in France (Lefort-Buson and Dattée, 1982a and 1985a) ; also, crosses between Canadian and European material were superior to crosses between Canadian lines in Canada (Grant and Beversdorf, 1985).

The aim of the paper is (i) to confirm these preliminary results refering to differences between crosses from lines of same and different geographic origins respectively, and (ii) to compare different groups of F1 hybrids, from a genetic point of view.

MATERIAL AND METHODS

1. Experimental design

European and Asiatic lines, both selfed for at least 6 generations, were hand-crossed following the cross-design of table 1. The sample of Asiatic lines used in the experiment was very limited, because only few of them survived winter climatic conditions in France. For European material, different lines were used for each experimental year, in order to draw conclusions from a larger sample of parental lines.

Three groups of F1 hybrids were established :

- the european group, refered to as ExE, from a diallel cross between European lines ;
- the Asiatic group, refered to as AxA, from a diallel cross between Asiatic lines ;
- the mixed group, refered to as ExA, from a factorial cross between European and Asiatic lines.

TABLE 1 Crosses design for 1984 and 1985

1984		Asiatic lines					European lines					
		Hokkaido	Mirvani	Asahi	Yudai	Mangui	R 41	Darmor	Quinta	Korina	Gorgzamsei	
1	Hokkaido	x	x	x	x	x	x	x	x	x	x	
2	Mirvani			x	x	x	x	x	x	x	x	
3	Asahi		(AxA)	x	x	x	x	x	x	x	x	(ExA)
4	Yudai				x	x	x	x	x	x	x	
5	Mangui					x	x	x	x	x	x	
1	R 41						x	x	x	x	x	
2	Darmor							x	x	x	x	
3	Quinta							(ExE)	x	x	x	
4	Korina									x	x	
5	Gorgzamsei										x	

1985		Asiatic lines				European lines						
		Hokkaido	Aburamasari	Asahi	Yudai	Bienvenu	Darmor	61.4M	Niemerczanski	.12	Garant	
1	Hokkaido	x	x	x	x	x	x	x	x	x		
2	Aburamasari			x	x	x	x	x	x	x	x	
3	Asahi		(AxA)	x	x	x	x	x	x	x	x	(ExA)
4	Yudai				x	x	x	x	x	x		
1	Bienvenu					x	x	x	x	x		
2	Darmor						x	x	x	x	x	
3	61.4M							x	x	x		
4	Niemerczanski							(ExE)	x	x		
5	B.12									x	x	
6	Garant											

Because of technical problems in seed production, some crosses of the design were not successfull (see table 1) and could not be evaluated. Elsewhere, some crosses were very successfull and evaluated both in Le Rheu (INRA) and at Prémesques in the North of France (RINGOT). In le Rheu, randomized complete block designs with 4 replications were planted for each group. Because the lack of seeds, European and Asiatic parents were planted only with their respective groups ; however, the 3 elementary designs included common checks : Bienvenu, Jet 9, and Darmor. Plots had six 5m long rows with 0.30m between rows. Four characters were measured in the inner rows of the plots to avoid competition effects (Azaïs et al.) 1986) : height at flowering time (in cm, seed yield (in qls/ha), yield per pod (in mg, evaluated from 3-plot samples of 50 pods), and 1000-seeds weight (in g, evaluated from 1 plot sample of about 1000 seeds, first counted and then weighed). In Prémesques, only seed yield was evaluated from micro plots (harvested area of 2 m²) in randomized block designs.

2. Statistical analysis

A classical 2-way (block, entry) analysis of variance was computed for each group. A preliminary analysis was conducted to look at the stability of checks over the 3 groups : there were no interactions between checks and groups whatever he character, but group differences were significant for few characters. To enable the comparison of the 3 groups in the following, few characters were ajusted in each group considering the magnitude of average group effect on checks. The means of F1 hybrids were statistically

compared (Student's tests) to the mean of parental lines on one hand, and to Bienvenu on the other hand.
A fixed-effect model was used for the analysis of variability in different groups, because both Asiatic and European parental lines samples were of small size. In the two dallels (ExE and AxA), variability was divided following Griffing (1956, model 1 method 4). Both parameters $\Sigma gi^2/(p-1)$ and $\Sigma sij^2/[p(p-3)/2]$ were calculed to estimate the variability for both general (GCA) and specific (SCA) combining abilities en European and Asiatic material. In the factorial design (ExA), a 2-way analysis of variance (average effects of Asiatic and European parents, interaction between both types of parents) was made. And the decomposition of mean squares' expectations (Snedecor and Cochran, 1967) gave an estimation of variability for average and specific combining values in the ExA group. In the following, estimates of variability for general and specific combining abilities in European or Asiatic group, were refered as $k^2_{E/E}$ or $k^2_{A/A}$ (general), and k^2_{ExE} or k^2_{AxA} (specific). In the mixed group variability of average effects was refered as $k^2_{E/E.A}$ or $k^2_{A/E.A}$, and variability of interactions as k^2_{ExA}. Comparisons of variability parameters (k^2) were made within and between groups (no statistical test was done, because of poor accuracy of k^2 parameters). Also, the ranks of parental lines when crossed with lines of same origins and with lines of different origins were compared.

RESULTS

1. Heterosis in the three groups

In 1984, whatever the group, F1 hybrids were significantly superior to mean parents for height, seed yield and yield per pod (except yield per pod in ExE group). However, in 1985, only seed yield heterosis was significant in ExE and ExA groups (table 2).

TABLE 2 : *Superiority of hybrids over mean parent and check Bienvenu respectively, in the three groups, in 1984 (a), in 1985 (b) at Le Rheu.*

		Average hybrid vigour related to mean parent (c)			Superiority of hybrids over the check Bienvenu		
		E x E	E x A	A x A	E x E	E x A	A x A
Number of	(a)	10	15	3	10	25	9
F_1 hybrids	(b)	10	15	3	12	22	6
HEIGHT	(a)	7.4 * or 7%	21.0 * or 21%	11.4 * or 12%	17.8 * or 19%	24.1 * or 26%	-1.13 or -1%
	(b)	5.0 or 4%	9.4 or 8%	9.3 or 3%	17.1 * or 15%	10.5 * or 10%	1.32 or 1%
YIELD	(a)	2.16* or 8%	9.32* or 34%	8.89* or 32%	-5.31* or -14%	7.26* or 25%	6.50* or 24%
	(b)	6.98* or 16%	16.45* or 45%	0.03 or 0.1%	-2.24 or -4.4%	3.96* or 8%	-17.57* or -34%
YPP	(a)	-1.62 or -3%	23.4 * or 46%	11.5 * or 20%	2.54 or 4.5%	20.6 * or 41%	22.9 * or 58%
	(b)	0.27 or 0%	3.1 or 4%	3.0 or 4%	7.53 or 10%	7.0 or 9%	12.3 or 17%
W1000	(a)	0.14 or 4%	-0.07 or -2%	0.04 or 1%	0.96* or 23%	0.78* or 21%	-0.54 or -13%
	(b)	0.06 or 1%	0.07 or 2%	-0.08 or -2%	-0.07 or -2%	0.05 or 1%	-0.15 or -4%

(c) Because of the lack of parental seeds, estimations of hybrid vigor related to parental mean did not include all F1 hybrids, but only those that had both parents in a test.

* Significant for a 5 % level

Although not always significant, **heterosis in the ExA group was higher than heterosis in ExE or AxA group.** W1000 was not heterotic at all, as was expected (Lefort-Buson and Dattée, 1985a ; Grant and Beversdorf, 1985).
Hybrids were taller than Bienvenu in both ExA and ExE groups, and as tall as Bienvenu in the AxA group (table 2). In 1984, ExA and AxA F1 hybrids were more productive than Bienvenu, whereas ExE F1 hybrids were less productive than this check (table 2) ; in 1984, particularly mild temperatures may have accounted for the high production of Asiatic varieties, whose yield must have been overestimated. In 1985, only the mixed group F1 hybrids outyielded the check, whereas AxA hybrids were very poor in seed production (table 2) ; in 1985, there was a serious frost during winter, and Asiatic varieties were disavantaged, as was expected. Considering the two different climatic years, in average **ExA F1 hybrids outyielded both ExE and AxA F1 hybrids as well as check Bienvenu.** These results are consistent with those of Shiga (1976) in Japan, who found that ExA hybrids outyielded AxA hybrids.

2. Composition of variability

Residual variances have been compared over the 3 groups (Bartlett's test), and are homogeneous : so, all entries whatever their group seemed to give similar responses to the environment. **SCA variability was neither significant nor important compared to GCA variability, in both European and Asiatic groups** (table 3). Previously, Lefort-Buson and Dattee (1982b, 1985b) and Olivieri and Parrini (1983) had also found a predominance of GCA effects over SCA effects in a population of European hybrids. **On the contrary, in the mixed group, specific effects were significant and as important as mean effects for most cases** (table 3). These last results were consistent with those of Grant and Beversdorf (1985), who worked with F1 hybrids from lines of different origins (Canada, Denmark and Sweden).

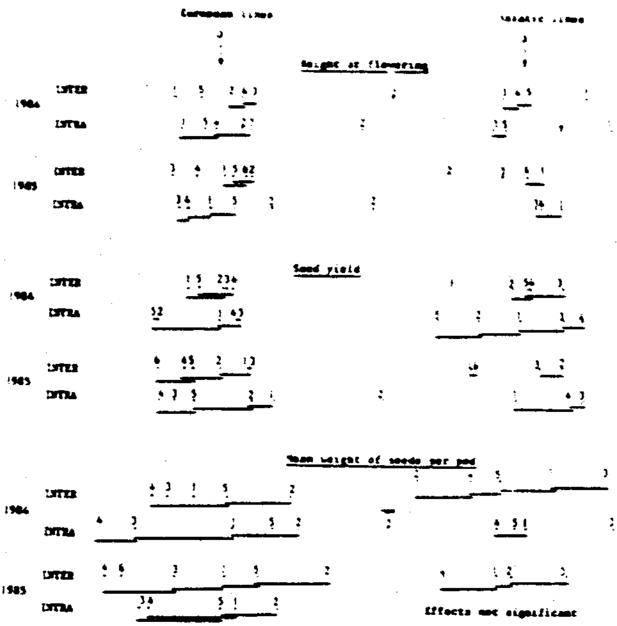
TABLE 3: Estimates of variability parameters /k^2/ in the three groups, in 1984 /a/ and 1985 /b/, and for the three heterotic characters.

		Average parental effects in				Interaction effects in		
		Europen group	Asiatic group	Mixed group		Europen group	Asiatic group	Mixed group
Character		$k^2_{E/E}$	$k^2_{A/A}$	$k^2_{E/E.A}$	$k^2_{A/E.A}$	k^2_{ExE}	k^2_{AxA}	k^2_{ExA}
HEIGHT	a	19.42	212.2	22.14	118.6	8.62	32.7	13.33
/Le Rheu/	b	34.10	183.0	18.22	45.82	1.22	NS	47.67
YIELD	a	4.08	13.32	1.69	5.52	NS	NS	5.34
/Le Rheu/	b	7.69	31.47	2.86	5.66	NS	NS	6.68
YIELD	a			0.80	3.29			2.26
/Premesques/	b			1.06	2.42			4.17
YPP /Le Rheu/	a	47.13	57.45	19.61	40.66	NS	NS	NS
	b	22.34	NS	49.83	15.35	NS	NS	30.14

NS is indicated when effects are not significant in the analysis of variance

Elsewhere, **Asiatic mean parental effects were nearly always greater than European effects,** suggesting a greater variability within Asiatic material. And, in all cases except yield per pod in 1985, variability of mean parental effects in the diallels (either European or Asiatic) was grater than variability of the same effects in the mixed group (table 3). For both height and seed yield per pod, however, parental lines did behave similarly when crossed within or between sets of lines (figure 1).

FIGURE 1 : Mean lines effects when crossed within (INTRA) and between (INTER) sets of lines



Concerning seed yield, few lines were performant when crossed between different set of lines, and bad producer when crossed within one set of lines.

DISCUSSION AND CONCLUSION

The consistency of results from various studies in Japan (Shiga, 1976), in Canada (Grant and Beversdorf, 1985) and in France (this experiment) emphasizes the interest in producing F1 hybrids whose parents have very different geographic origins. In this particular case, the Asiatic material seemed very advantageous, firstly because of its good complementarity with European material and, secondly because of its large potential variability. The enlarged variability of Asiatic material could be due to the great use of B. campestris, for B. Napus breeding in Japan. The great variability of Asiatic material has also been shown in case of selfed-lines breeding (Lefort-Buson, unpublished) : The variance of lines which could be derived from one cross for seed yield was greater in case of one ExA combination compared to one ExE combination. However, today the use of Asiatic material for breeding puposes raises some problems : Asiatic lines are susceptible to Phoma Lingam and not improved for quality characteristics (erucic acid rate and glucosinolates content). Therefore, a **preliminary breeding work has to be made before using Asiatic lines for selection.**

The statistical variability of seed yield and height was not organized the same way in crosses including lines of same and different origins, and suggests differences between groups in composition of genetic variability. In either the European and Asiatic group, variability revealed in crosses was mainly additive : most epistatic effects must have been integrated in blocks of favorable genes, during the breeding process. However, favourable genes which have been accumulated in European and Asiatic groups, might be different within both groups because of diversified origins of material, low migration process between origins, and different environments. **The interaction of such different genes may induce new dominance and epistasis relationships between genes** and lead to the occurence of statistical interaction effects. The new relationships between different genes, which gave evidence of good complementarity between European and Asiatic material, lead to the high yielding ability of ExA F1 hybrids.

Elsewhere, for height and mean weight of seeds per pod, the ranking of mean parental effect was similar in crosses within and between groups, suggesting that the additive effects of parents were expressed the same way, whatever the group. On the contrary, **for a complex character as seed yield, the expression of additive effects seemed to depend on the genetic environment.**

The study of Asiatic material for breeding purposes and genetic developments has brought new interesting information. It emphasizes the interest of diversified origins for selection of F1 hybrids, and raises important questions concerning the composition of variability in crosses within and between populations. However, results have to be confirmed with a larger sample of parental lines before being used in F1 hybrids breeding schemes.

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