Analysis of Yield Components of F1 Hybrids of Crosses between Spring and Winter Wheat Types (*Triticum aestivum* L.)

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SUMMARY

F1 hybrids were produced using the German spring wheat variety Remus as a female parent and eight Croatian wheat varieties (six winter and two spring types) as male parents. The heterosis (MP-mid parent, BP-better parent) for five yield components was investigated in eight cross combinations. Data are based on field trial.

All the combinations tested gave average heterosis (MP, BP) for 1000-grain weight (14.38%, 6.12%) and grain weight per spike (11.47%, 3.68%). The highest heterosis (MP, BP) was found for 1000-grain weight (35.27%, 28.42%) in the hybrid Remus/Sivka and for grain weight per spike (20. 45%, 19.1%) in the hybrid Remus/Dukat.

These data showed that the spring wheat variety Remus could be used in cross combinations for improvement of yield through higher 1000-grain weight and grain weight per spike.

KEY WORDS

heterosis, cross combination, yield components, growth habit, wheat

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Received: September 16, 2003

INTRODUCTION

It has been hypothesised that an increase in genetic difference between parents will positively increase heterosis for grain yield. Parents which differ genetically can produce a hybrid with a better yield performance. On the basis of theoretical and practical considerations in different crops a large heterotic effect can be expected by combining parents from two different germplasms; for example spring and winter wheat types. Crosses between winter/spring types have proved to show higher hybrid vigour than crosses derived from winter/winter or spring/spring germplasm (Pickett, 1993; Kronstad, 1996).

However, Jordaan et al. (1999) reported that diversity between spring wheat types, winter wheat types or between different germplasms (breeding programs) can result with heterosis, but not necessarily. Fabrizius et al. (1998), also exploring the heterosis of wheat, found that crosses of parents unrelated by pedigree expressed greater heterosis than crosses of related parents. The opposite was found by Cox and Murphy (1990) and Picard et al. (1992); they claimed that the correlation between heterosis and genetic distance based on pedigree was small or non-existent in hard red wheat and soft wheat.

Based on the investigation in different crops, Melchinger (1999) also reported about different correlation between parents genetic distance and heterosis. In some cases that correlation was strong in crosses among more or less related parents (lines), weak correlation was noticed in crosses among non-related lines, whereas no correlation was found if parents belonged to different gene pools._

Selection of parents differing in yield components might be a precondition for obtaining heterosis for yield, as claimed by Liu and Rao (1997). Barić et al. (2000) also observed that crosses of parents that differ in one or several traits gave higher probability for obtaining superior progeny. The genetic mechanism of heterosis enables the selection of parents and early diagnosis of the breeding value of hybrid combination (Saakyn, 1991). Therefore, the objective of this paper was to investigate heterosis (MP, BP) for five yield components in crosses between the German wheat variety Remus (spring type) as female parent with a high grain weight and eight Croatian wheat varieties (six winter, two spring) and to identify the combinations with strong yield heterosis.

MATERIALS AND METHODS

Six winter wheat varieties: Sivka, Banica, Magdalen, Lipa, Marija and Dukat, and two spring wheat varieties Vidovica and Brđanka (genotypes from different breeding programs in Croatia), were crossed with the German spring wheat variety Remus (used as a female parent). The parent's varieties had different pedigrees.

The parents and F1's were grown during 1998/99 in the experimental nursery of the Faculty of Agriculture in Zagreb (Croatia). The eight F1's and nine parents were arranged randomly in a complete block design with three replications. Two row plots of 105 cm in length, with a 20-cm row distance and 7 cm between plants were used respectively. After harvest ripeness, 20 main spikes per plot were collected and used for evaluation of five yield components: number of spikelets per spike, grain number per spikelet, grain number and grain weight per spike and 1000-grain weight.

Data were analysed by the ANOVA and LSD tests. Mid parent heterosis (MPH) and better parent heterosis (BPH) were calculated according to the formulae:

$$MPH=(F1-MPV)/MPV \times 100,$$

$$BPH=(F1-BPV)/BPV \times 100;$$

MPV is the mid parent value, BPV is the value of the better parent in a cross and F1 is the value of F1 hybrids.

RESULTS

Phenotypic expression of yield components of the parents and F1 hybrids

Mean values of the phenotypic characteristics of the parents and F1 hybrids are shown in Table 1. Remus had significantly higher 1000-grain weight (45.84g) than Dukat (37.95g), Lipa (37.91g), Marija (35.66g), Banica (35.69g) and Brđanka (33.93g), and significantly higher grain weight per spike (2.61g) than Sivka (2.16g), Vidovica (1.89g) and Brđanka (1.81g).

Parental genotypes Dukat, Remus, Magdalen, Banica and Marija had high mean values for most yield components: number of spikelets per spike ranging from 22 to 24.1, grain weight per spike from 2.33 to 2.67g, grain number per spike from 61.33 to 66.6 and 1000-grain weight between 42.82 and 45.84 g. Vidovica and Brđanka are spring wheat varieties with the lowest mean values for all traits, except for the 1000-grain weight (Vidovica) and grain number per spikelets (Brđanka).

A large number of yield components with high mean values was found in F1 hybrids of Remus with Dukat, Lipa, Magdalen and Banica. The highest mean value for 1000-grain weight was found in F1 hybrids Remus/Sivka and Remus/Vidovica.

Heterosis in cross combinations

Table 2. shows the heterosis (MP, BP) for yield components for all F1 hybrids. For 1000-grain weight the MP heterosis ranged from 4.02% to 35.27% and

Table 1. Average values for five yield components of parents and F1 hybrids

Cross	Number of spikelets	Grain number/ spikelet	Grain number in main spike	Grain weight (g)	1000 grain weight (g)
Remus	22.00	2.59	57.00	2.61	45.84
Remus x Sivka	21.40	1.84	39.27	2.31	58.87
Sivka	20.60	2.54	52.47	2.16	41.20
Remus x Banica	22.60	2.60	58.78	2.82	47.95
Banica	23.27	2.63	61.33	2.33	35.69
Remus x Magdalen	22.73	2.66	60.53	2.85	47.08
Magdalen	23.47	2.42	56.73	2.43	42.82
Remus x Lipa	21.73	2.94	61.13	3.02	47.60
Lipa	20.73	3.06	63.47	2.40	37.91
Remus x Marija	22.40	2.48	55.67	2.51	45.68
Marija	24.07	2.74	65.80	2.35	35.66
Remus x Dukat	22.87	2.82	64.47	3.18	43.58
Dukat	23.53	2.96	66.60	2.67	37.95
Remus x Vidovica	19.40	2.52	48.87	2.65	54.27
Vidovica	17.25	2.47	42.57	1.89	44.47
Remus x Brđanka	22.20	2.44	54.80	2.38	43.49
Brđanka	18.97	2.80	53.17	1.81	33.93
LSD (0.05)	1.592	0.273	7.405	0.273	5.692

Table 2. Heterosis (%) (MPH, BPH) for five yield components of F1 hybrids

Cross		Number of spikelets	Grain number/ spikelet	Grain number in main spike	Grain weight (g)	1000 grain weight (g)
Remus x Sivka	MPH	0.47	-28.27*	-27.95*	-3.15	32.27*
	BPH	-2.72	-28.96*	-31.11*	-11.49	28.42*
Remus x Banica	MPH	-0.16	-0.38	-0.65	14.17*	17.63*
	BPH	-2.88	-1.15	-4.16	8.05	4.6
Remus x Magdalen	MPH	-0.50	6.19	6.45	13.09*	6.2
	BPH	-3.15	2.71	6.19	9.19	2.71
Remus x Lipa	MPH	1.71	4.07	1.49	20.56*	13.65*
	BPH	-1.23	-3.92	-3.69	15.71*	3.84
Remus x Marija	MPH	-2.76	-6.94	-9.33	1.21	12.1
	BPH	-6.94	-9.49	-15.39*	-3.83	-0.35
Remus x Dukat	MPH	0.46	1.62	4.32	20.45*	4.02
	BPH	-2.81	-4.73	-3.19	19.1*	-3.49
Remus x Vidovica	MPH	-1.15	-0.39	-1.84	17.77*	20.16*
	BPH	-11.82*	-2.70	-14.26*	1.53	18.37*
Remus x Brđanka	MPH	8.37*	-9.46	-0.52	7.69	9.04
	BPH	0.91	-12.86	-3.85	-8.81	-5.13

* = significant at the 0.05 probability level

the BP heterosis from -5.13% to 28.42%. For grain weight per spike the MP heterosis ranged from -3.15% to 20.56% and the BP heterosis from -11.49% to 19.1%.

For grain weight per spike significant positive heterosis (MP, BP) was found in combinations Remus/Dukat and Remus/Lipa, and in combinations Remus with Banica, Magdalen and Vidovica only MP heterosis was significant. For 1000-grain weight significant positive heterosis (MP, BP) was found in combinations Remusa/Sivka and Remus/Vidovica while in combinations Remus/Banica and Remus/Lipa only the MPV heterosis was significant. For number of spikelets per spike significant positive MP heterosis was found only in cross Remus/Brđanka.

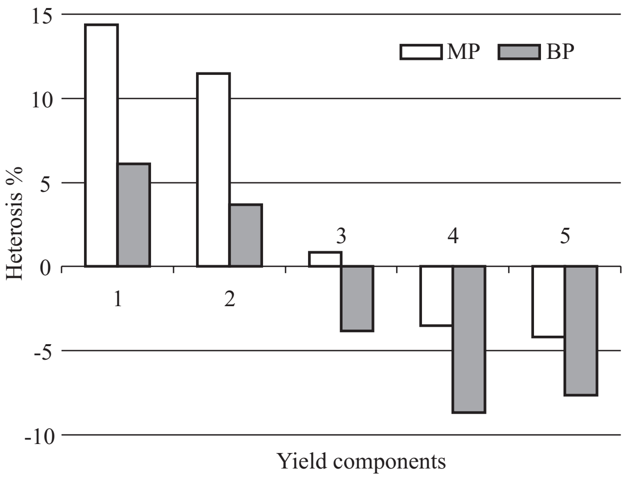

Figure 1. Heterosis (%) (MP, BP) for yield components averaged over crosses
Yield components: (1) 1000 grain weight, (2) grain weight per spike, (3) number of spikelets per spike, (4) grain number per spike, (5) grain number per spikelet

Negative heterosis (MP, BP) for grain number per spike was displayed by the combination Remus/Sivka, and in combinations Remus/Marija and Remus/Vidovica only BP heterosis was negative.

In Figure 1. heterosis (MP, BP) for yield components (average of all crosses) is represented. Positive heterosis (MP, BP) was found for 1000-grain weight (14.38% and 6.12% respectively) and grain weight per spike (11.47% and 3.68% respectively). For number of spikelets per spike only slightly positive MP heterosis (0.85%) was found.

DISCUSSION

The precondition for obtaining high frequency of positive heterosis is the selection of genetically different parents with high mean values for certain traits and ability of good mutual combination. In pursuit of a maize model (heterotic groups), endeavours have been made for wheat to cross the parents which differ genetically (pedigree, growth habit, gene pool) in order to obtain a positive heterotic effect in cross combinations.

Some authors (Pickett, 1993; Kronstad, 1996) presumed that the difference between winter and spring types will result in an expression of higher vigour in offspring. Therefore, in the current investigation the spring wheat variety Remus was included, which differed from all Croatian wheat varieties in pedigree and from six of them also in the growth habit. In four out of six cross combinations between spring wheat variety Remus and Croatian winter wheat varieties a significant positive heterosis was found for grain weight per spike, while for 1000-grain weight the same was observed in three cross combinations (Table 2). However, a significant positive heterosis for 1000-grain weight was also obtained when the spring wheat variety Remus was crossed with the spring wheat variety Vidovica and for number of spikelets per spike when Remus was crossed with spring wheat variety Brđanka. According to these results, it seems that only part of heterosis could be imputed to the genetic difference in growth habit. The manifestation of positive heterosis in hybrid combinations is not solely the result of parental divergence; in offspring of divergent parents heterosis will be expressed only if chosen parents possess the ability for good mutual combination.

Most yield components of heterotic hybrids were not related to the genetic distance between parents (Martin et al., 1995; Perenzin et al., 1998). Cox and Murphy (1990) and Barbaso-Neto et al. (1996) in some cases could also not find high heterosis in hybrids obtained from crossing different parents. Moreover, in the present study for grain number per spike high negative heterosis (MP, BP) was obtained in the cross Remus/Sivka.

Breeding for such a complex trait as yield is, is very complicated. It is hard to predict which combinations of yield components will produce heterosis for yield and which yield components will have a greater share. Bos and Sparnaaij (1993) attempted to calculate recombined heterosis for yield through yield components. Following this method, Barić et al. (1998) and Barić et al. (2000) found that grain weight, as the main yield component, had a great share in yield.

Grain weight is determined by the female genotype (Liu and Li, 1994). The same authors found a high heterosis for grain weight. Beside the difference in pedigree, this was s second reason that Remus was used as a female parent with high 1000-grain weight and grain weight per spike. Positive significant heterosis (MP, BP) (average of all crosses) was found for 1000-grain weight (14.38% and 6.12% respectively) and for grain weight per spike (11.47% and 3.68% respectively) (Fig. 1). The MP heterosis for grain weight per spike ranged from –11.5 to 20.56%, while in the investigations of Winzeler et al. (1994) the heterosis values were ranging between 29.9 to 47.6%.

Increasing the heterosis of grain weight will be to the benefit of yield, because grain weight has been considered a mostly independent yield component and its level of expression would not produce a compensating change in other components (Liu and Li, 1994). Morgan (1998) found that the positive heterosis for the mean grain weight is a result of heavier grains.

The probability for expression of positive heterosis appears to be greater if parents with high mean values for a trait/traits are combined. This finding was proved by our investigations in which F1 hybrids with positive heterosis were noticed in combinations of parents with high mean values (Remus with Dukat, Lipa, Banica, Magdalen).

However, in the combination Remus/Marija it was noticed that parents with high mean values for a trait were combined and negative BP heterosis for all traits was found. Similarly, Krishna et al. (1992) obtained the best progeny for yield in all combinations between high- and low-yielding parents.

CONCLUSION

Significant positive heterosis was found for grain weight in five combinations and for the 1000-grain weight in four combinations. These data showed that the spring wheat variety Remus is suitable as a parent in crosses with different Croatian wheat varieties from which progeny with an improved yield is to be expected.

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acs69_02