GENETIC VARIABILITY OF RYE-XENIC-HYBRID TRAITS

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(Received: December 20, 1995. Accepted: May 25, 1995.)

ABSTRACT

In field experiments performed in two localities (Smolice, Wrocław) 18 xenic hybrids of winter rye, two testers and standard cultivar Dańkowskie Żłote, were analysed. The objects of detailed evaluations were 11 traits. For six of them arithmetic means ($\bar{x}$), standard deviations (S), coefficients of variation (cv), coefficients of genetic diversity (h^2), correlation coefficients were calculated. Moreover, analyses of variance were carried out and the effects of general (GCA) and specific (SCA) combining ability were estimated. The existence of quantitative xenia in hybrids was confirmed. It was shown that xenic hybrids, in respect to most of the analysed traits, were insignificantly inferior to the testers and the standard cultivar. However, the decrease of plant height has shown to be significant and a tendency to higher yield was observed.

KEY WORDS: rye (*Secale cereale* L.), xenia, xenic hybrids.

INTRODUCTION

The xenia phenomenon in rye (*Secale cereale* L.) enables to separate hybrid seeds from ears of yellow – grain maternal forms, pollinated by pollen of plants with green grain. Hybrid seeds have a green seed cover and frequently a higher unitary mass. We suggest to name the obtained this way hybrids as xenic hybrids. The possibility of their production allows to formulate a new breeding idea of producing hybrid cultivars (Grochowski 1990, Grochowski et al. 1995a, b, Kadłubiec et al. 1995). The hitherto methods of practical use of rye heterosis were based on mass crossing with use of cytoplasmic male sterility (CMS) (Geiger 1985, Miedaner and Geiger 1993, Madej 1984). These are rather expensive and relatively difficult in preserve breeding and seed production. It was shown in earlier works of Grochowski and co – authors (1990, 1995a, b) that xenic hybrids create new perspectives of producing hybrid cultivars disregarding CMS. The condition of introducing this method is to have a valuable initial material of very high crossing ability (Grochowski et al. 1995a). High heterosis in rye is very rare (Węgrzyn 1988), therefore having at disposal a relatively low number of inbred lines of yellow grain, it was not expected to develop significantly better hybrids, but equaling in level of traits with testers and the standard. It may be expected that in a broader genetic material distinctly better combinations will appear (Bujak et al. 1995, Grochowski et al. 1995b, Kadłubiec et al. 1995).

The aim of the present work was:

- to check, whether the phenomenon of quantitative xenia (higher 1000 grains weight of green grains in relation to

yellow grains, originating from the same plants of different hybrids) will be confirmed in a field experiment;

- to compare the level of bonitation traits and of several elements of the crop structure of xenic hybrids with testers and the standard cultivar Dańkowskie Żłote.

Earlier results of our studies (Kaczmarek et al. 1992) allow to accept the assumption, that for reaching the aim of the work, it is sufficient to perform the experiments in two different localities.

MATERIAL AND METHODS

The material for the experiment included:

- a) 18 hybrids F1 of winter rye, produced in topcross nurseries, in which 9 inbred lines of yellow grain were crossed with two testers: the cultivar Madar and the population Krótka I,
- b) the testers Madar and Krótka I,
- c) the standard Dańkowskie Żłote.

The study was carried out in the years 1993-1995. The obtained in 1994, from topcross nurseries, hybrid seeds were sown in two localities (Smolice, Wrocław). The experiments were established by means of random blocks in four replicates. The objects were sown singly at spacing 20 x 5 cm on 1m² plots. Subject to detailed analysis were 11 traits: emergence, winter hardiness, infection with brown rust, lodging (scale 1-9), heading (in days, from 1st May on), height of plants (cm), number of fertile ears per 1m², grain yield from plot (g), weight of grains per ear (g), 1000 grains weight (g), hectolitre weight (kg). For six traits calculated were: arithmetic means ($\bar{x}$), standard deviations (S), coefficients of vari-

ation (cv), coefficients of genetic diversity (h^2), correlation coefficients (r), furthermore, analyses of variance were performed and the effects of general (GCA), and specific (SCA) combining ability were estimated.

RESULTS AND DISCUSSION

The produced xenic hybrids should have been characterized, apart of fertility, by high evaluations of bonitation

traits. Table 1 includes the mean values of bonitation traits, in a 9-degree scale. The comparison of hybrids with testers and the standard indicates their high similarity. Only in the case of number of days from May 1st until coming into ear, the tester Krótka I and two hybrids (70617 x Krótka I and 70620 x Krótka I) were 3 days later than the standard. From among the studied hybrids, two came into ear simultaneously with the cultivar Dańkowskie Złote and the remaining ones were later.

TABLE 1. Mean values for analysed traits of testers, hybrids and standard (Dańkowskie Złote). Smolice, Wrocław 1995.

Trait	1		2		3		4		5	
	Emergence		Winter hardiness		Brown rust		Lodging		Heading days after 1st May	
	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I
Mean of testers	1.5	1.9	1.5	2.0	3.4	3.1	1.6	1.2	11.1	12.5
70474	2.1	1.9	2.0	1.7	3.9	3.9	1.9	2.9	11.6	11.0
70545	2.9	3.0	2.2	2.6	3.4	3.6	2.2	1.6	9.9	10.0
70551	2.1	2.1	1.6	2.9	3.7	3.5	2.2	1.9	10.8	10.0
70556	2.1	2.5	1.9	2.0	3.2	3.5	2.2	2.0	10.5	10.8
70610	2.5	2.1	2.5	2.1	3.6	3.1	2.1	1.9	11.3	10.6
70617	2.2	2.6	2.0	2.6	3.5	3.6	2.0	1.6	12.1	12.6
70620	2.1	1.6	2.0	2.0	3.5	3.4	2.1	1.9	11.6	12.8
70621	2.0	1.9	1.7	2.4	3.6	3.4	1.6	1.9	9.9	10.8
70677	2.1	2.1	2.2	1.7	3.7	3.6	2.0	1.9	10.5	11.4
Mean of standard	2.2		2.1		3.7		1.2		9.8	

TABLE 2. Mean values of traits of testers, hybrids and standard (Dańkowskie Złote). Smolice, Wrocław 1995.

Trait	1		2		3		4		5		6	
	Plant height cm		Number of fertile ears per m ²		Grain yield g/plot		Weight of grains per ear		1000 grains weight		Hectolitre weight kg	
	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I	Madar	Krótka I
Mean of testers	138.9	121.9	460	434	1041	1008	2.23	2.29	37.0	37.3	73.80	72.61
70474	131.3	132.0	465	450	1064	1061	2.45	2.38	41.7	40.5	74.16	74.03
70545	130.8	124.6	468	459	979	938	2.13	2.05	38.0	37.4	73.99	72.86
70551	132.4	125.9	506	429	1021	1011	2.03	2.38	38.9	38.9	73.56	73.28
70556	134.6	130.5	463	491	998	1043	2.21	2.13	40.6	39.2	74.49	73.73
70610	135.0	124.8	490	483	961	992	1.98	2.21	40.3	38.6	76.49	74.15
70617	132.4	123.1	465	424	972	986	2.13	2.36	39.4	39.2	74.62	74.17
70620	136.3	131.8	443	454	1051	1117	2.42	2.49	39.8	37.7	74.73	74.46
70621	136.0	130.6	484	449	1048	1029	2.20	2.38	40.7	38.9	74.51	75.05
70677	133.5	133.3	443	449	999	1023	2.30	2.33	38.9	41.1	73.86	74.25
Mean of standard	143.5		459		961		2.25		41.8		74.65	
LSD (0.05)	6.3								1.5			

The mean values of six yield-structure traits are presented in Table 2. Among exceptionally favourable traits, the significantly lowered height of hybrids in relation to the standard cultivar Dańkowskie Żłote and heightened 1000 grains weight in numerous hybrids, as compared with testers (paternal forms), should be included. The number of ears per 1m², grain yield from plot, grain weight from ear and hectolitre weight of the hybrids did not exceed the tester, and standard values. The statistical variability parameters of the studied traits are presented in Table 3. The highest variability, expressed by the cv coefficient, was found for grain weight from ear (20,3%) and number of ears per 1m² (16,3%). The analysis of variance has shown for plant height and 1000 grains weight a significant differentiation between genotypes and the coefficient of genetic differentiation h^2 was 0.35 and 0.49. This coefficient revealed very low values for the remaining traits.

TABLE 3. Genetics – statistical parameters of hybrids. Smolice, Wrocław 1995.

Parameter	Plant height cm	Number of fertile ears per m ²	Grain yield g/plot	Weight of grains per ear g	1000 grain weight g	Hectolitre weight kg
x	131.0	461.81	1015.89	2.25	39.42	74.24
S	9.09	75.04	134.83	0.46	2.21	1.96
cv [%]	6.87	16.30	13.23	20.30	5.61	2.64
h^2	0.35	0.01	0.03	0.10	0.49	0.06

The mean square of variability for environments, genotypes, general and specific combining ability, together with interactions, are given in Table 4.

Worthy of notice is the significant difference between environments, with a simultaneous lack of interaction G x E; this proves the stability of genotypes. From among the six ana-

lysed traits, the height of plants and 1000 grains weight distinguished the hybrids significantly. For these traits the analysis of general, and specific combining ability was performed. On the basis of the quotient GCA to SCA it was concluded on additive forms of gene action in height of plants and on the predominance of additive over nonadditive forms of gene action in 1000 grains weight. Table 5 presents the effects of GCA of maternal and paternal forms and the effect of SCA of hybrids for 1000 grains weight. Lines 70545 and 70617 influence significantly the shortening of stem length in progeny, whereas line 70474 increases 1000 grains weight. The tester Krótka I influenced the decrease of plant height, whereas the second tester improved the 1000 grains weight. The material of the discussed experiments has been taken from two topcross nurseries, established in 1993. In the paper by Grochowski et al. (1995b in press) the evaluation of maternal lines in respect of 1000 grains weight, effect of quantitative xenia and crossing value are presented.

Comparing these values with the general and specific combining value of the hybrids, the xenia effect in hybrid generation was found. Line 70677 was characterized by highest 1000 grains weight (34.28 g) and a 15% effect of quantitative xenia (Grochowski et al. 1995b in press) and in 1995 has had the same GCA value as the remaining lines, but at the same time, its hybrid with tester Krótka I attained the highest 1000 grains weight (Table 2) and a significantly positive SCA effect. The comparison of results of the discussed experiments and topcross nurseries from previous year confirmed the occurrence of the quantitative xenia effect in the hybrids studied.

For verification of logic relations between the analysed traits linear correlation coefficients have been calculated. Table 6 presents the correlation matrix. The correlations were significant for many pairs, but showed low values (from -0.71 between the number of productive ears per 1m² and grain weight per ear, to 0.21 between susceptibility to brown rust and lodging). As most important traits in our study recognized were: yield from plot and 1000 grains weight. The yield

TABLE 4. The mean squares of variability and combining ability.

Variability	Number of d. f.	Traits					
		Plant height	Number of fertile ears per m ²	Grain yield g/plot	Weight of grains per ear	1000 grains weight	Hectolitre weight
Environments (E)	1	1743**	172916**	27024	6.37**	58.45**	70.75**
Blocks x E	6	249.71	25357	86506.66	0.15	11.03	8.10
Genotype (G)	17	125.75**	3952.59	15017.41	0.19	11.39**	4.76
GCA of mothers	8	98.25*				14.66**	
GCA of testers	1	925**				19.89**	
SCA	8	52.97				7.06**	
Interaction G x E	17	44.31	3716.47	11845.65	0.15	3.76	3.29
GCA of mothers x E	8	53.53					
GCA of testers x E	1	212.75**					
SCA x E	8	14.03					
Error	102	40.29	3748.69	13235.45	0.13	2.33	3.73

* Significant at $\alpha = 0.05$

** Significant at $\alpha = 0.01$

is positively influenced by grain weight per ear ($r=0.44$) and negatively by brown rust infection ($r=-0.34$). The 1000 grains weight was positively influenced by resistance to lodging, and

negatively by a better winter hardiness. The obtained correlations confirmed the earlier results of studies with participation of the same maternal forms (Grochowski et al. 1994).

TABLE 5. Effects of general combining ability (GCA) of lines, testers and effects of specific combining ability (SCA).

Traits	CGA		SCA	
	Plant height cm	1000 grain weight g	1000 grain weight g	
Lines			Madar	Krótki I
70474	0.59	1.67*	0.20	-0.20
70545	-3.35*	-1.75*	-0.04	0.04
70551	-1.91	-0.53	-0.40	0.40
70556	1.53	0.50	0.33	-0.33
70610	-1.16	-0.008	0.50	-0.50
70617	-3.28*	-0.16	-0.29	0.29
70620	2.97*	-0.68	0.65	-0.65
70621	2.28	0.38	0.53	-0.53
70677	2.34	0.57	-1.48*	1.48*
Standard error	1.50	0.36	0.36	
Testers:				
Madar	3.48*	0.64*	* Significant at $\alpha=0.05$	
Krótki I	-3.48*	-0.64*		
Standard error	0.53	0.13		

TABLE 6. The correlation coefficients between investigated traits.

Traits	Emergence	Winter hardiness	Brown rust	Lodging	Heading days after 1st May	Plant height	Number of fertile ears per m ²	Grain yield per plot	Weight of grains per ear	1000 grain weight	Hectolitre weight
Emergence	1.00	-0.09	0.09	0.25*	0.18	0.18	0.23*	0.22*	-0.09	0.07	0.19
Winterhardiness		1.00	-0.08	-0.45*	-0.30*	-0.25*	-0.32*	0.23*	0.45*	-0.27*	-0.27*
Brown rust			1.00	0.21*	0.09	-0.15	-0.19	-0.34*	-0.06	-0.10	0.06
Lodging				1.00	0.15	0.16	0.03	-0.26*	-0.19	0.37*	0.17
Heading days after 1st May					1.00	-0.06	0.12	0.01	-0.13	0.07	0.14
Plant height						1.00	0.29*	0.09	-0.16	0.28*	0.23*
Number of fertile ears per m ²							1.00	0.23*	-0.71*	-0.05	0.20*
Grain yield per plot								1.00	0.44*	-0.07	-0.16
Weight of grains per ear									1.00	0.06	-0.29*
1000 grains weight										1.00	0.22*

* Significant at $\alpha=0.05$

CONCLUSIONS

1. The carried out study confirmed the occurrence of quantitative xenia (higher unitary mass of green grain) in xenic hybrids.
2. Most of the studied hybrids were insignificantly inferior to Dańkowskie Żłote in respect to the traits analysed.

Noteworthy is the statistically confirmed decrease of plant height and the distinct tendency to a higher yield.

3. From among maternal lines, as most interesting appeared, to be: 70545 and 70617, which significantly influence the shortening of the stem in progeny, line 70474 increasing in progeny the 1000 grains weight, and line 70620, which gives with tester Krótki I a hybrid of highest yield from plot.

4. The comparison of testers revealed that the cultivar Madar improved the 1000 grains weight, and the population Krótka I decreased the plant height in progeny.

ACKNOWLEDGEMENTS

This work was financially supported by grant No. 5 S 301 002 05 from the Polish Committee for Scientific Research (KBN)

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GENETYCZNA ZMIENNOŚĆ CECH MIESZAŃCÓW KSENICZNYCH ŻYTA

STRESZCZENIE

W doświadczeniach polowych prowadzonych w dwóch miejscowościach (Smolice, Wrocław) badano 18 mieszańców ksenicznych żyta ozimego, 2 testery oraz odmianę wzorcową Dańkowskie Złote. Przedmiotem szczegółowych ocen było 11 cech. Dla 6 z nich obliczono: średnie arytmetyczne ($\bar{x}$), odchylenia standardowe (S), współczynniki zmienności (V), współczynniki genetycznego zróżnicowania (h^2), współczynniki korelacji, a ponadto wykonano analizy wariancji oraz oszacowano efekty ogólnej (GCA) i swoistej (SCA) zdolności kombinacyjnej. Potwierdzono istnienie ksenii ilościowej u mieszańców. Wykazano, że mieszańce kseniczne pod względem większości analizowanych cech nie ustępowały istotnie testerom i odmianie wzorcowej. Natomiast istotne okazało się obniżenie wysokości roślin i przejawiała się tendencja do wyższego plonowania.

SŁOWA KLUCZOWE: żyto (*Secale cereale* L.), ksenia, mieszańce kseniczne.