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Genetic Sources with High Cold Resistance in Breeding of Poly-Rowed Barley (*Hordeum sativum* Jess., ssp. *vulgare* L.): I. Cold Resistance in F_1

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Abstract

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New genetic sources of high resistance were determined in breeding of poly-rowed barley (*Hordeum sativum* Jess., ssp. *vulgare* L.). The inheritance of cold resistance in F_1 in the reciprocal crosses occurred in the direction of the colder resistant parental component. Instances of super dominant heritability in F_1 were registered. Involving the winter poly-rowed barley varieties Mironovskiy 87 and Skorohod, for the first time in Bulgarian agriculture winter forms of poly-rowed barley varieties with unique high resistance were experimentally developed. They successfully survived the extremely low temperatures during the severe winter of 2003.

Key words: barley, breeding, cold resistance

Introduction

Bulgaria is situated in a zone of moderate continental climate and years with severe winters that can seriously damage barley are not rare. 1985 and 2003 were such years when large areas in North and South Bulgaria sown with barley were completely destroyed. Therefore Bulgarian breeding still owes much to production (Tsvetkov et al., 2000). A way out of this situation is to include genetic sources with high cold resistance in the hybridization programs. There are no such sources of Bulgarian origin in the National Gene Pool. In this respect the two-rowed and poly-rowed barley varieties from the Russian and Ukrainian breeding is of special interest; they could be used as donors of cold resistance in hybridization.

This paper considers the possibilities to use some Russian and Ukrainian genetic sources with high cold resistance in the breeding program of poly-rowed barley, and the ways of inheritance in F_1.

Materials and Methods

The experimental research work was carried out at Dobroudja Agriculture In-

stitute - General Toshevo, Bulgaria, during 1993-2003. The first stage (1993-1998) included searching and collecting of genetic sources with high resistance for the purposes of winter barley breeding. The object of investigation were the varieties Hemus and Veselets (poly-rowed barley varieties, standards of State Variety Testing in Bulgaria), Miraj (Romanian poly-rowed barley variety), Bastion and Skorohod (Russian poly-rowed barley varieties), and Mironovskiy 87 (Ukrainian poly-rowed barley variety). Winter resistance was studied under field conditions, and cold resistance - under laboratory conditions (Tsenov and Petrova, 1984). At different stages of freezing in chambers, temperatures of -12° C and -14° C (for the genetic sources) and of -13° C and -14° C (for the hybrids in F_1) were used. For comparing the experimental data on cold resistance the standard wheat varieties for cold resistance Bezostaya 1, No 301, Rousalka and San Pastore were used, as well as the Ukrainian barley variety Odeskiy 31. The systematic affiliation of the used varieties was determined according to Popova et al. (1955) and heritability in F_1 - according to Mather (1949).

Results and Discussion

Genetic sources of barley with high cold resistance

In breeding and improvement work on winter poly-rowed barley, the development of promising lines combining high productivity and high cold resistance was possible only in those cases when at least one of the parental components in the hybridization also possessed high cold resistance. This required paying a special attention to preliminary freezing in chambers at low negative temperatures and a wide range of own and foreign barley lines. During the period 1995-198 only, 937 lines and varieties of Bulgarian and foreign breeding were analyzed. It was established that the poly-rowed barley lines with high cold resistance were very rare. For the purposes of breeding, only lines Mironovskiy 87, Bastion and Skorohod were of special interest, or just 3.1 % of all lines. This percent was insufficient, especially for such a country as Bulgaria, where winter damages on barley crops are common.

The data given in Table 1 show that the poly-rowed barley varieties Miraj, Hemus and Veselets grown now in production have very low cold resistance which, by percent of surviving plants after freezing at -12° C, was equal to (or lower than) that of the least cold resistant standard, the Italian variety San Pastore (Table 1).

Against the background of this low cold resistance of the above barley varieties used in production, the cold resistance of the poly-rowed barley Mironovskiy 87 (pallidum Ser.) was very good (56 %); by this index the variety can be placed between the winter wheat varieties Roussalka (46.7 %) and No 301 (67.3 %) (Figure 1). In this respect the poly-rowed barley varieties Bastion (pallidum Ser.) and Skorohod (parallelum Korn) are of special interest for cold resistance breeding; averaged for three years the percent of surviving plants after freezing at -12° C was very high (65.0 and 69.0 %). By this index the barely varieties were equal to the wheat variety No 301, which was in the past widely distributed throughout in the country.

Table 1

Genetic sources of high cold resistance of poly-rowed barley, averaged for 3 years (1995-1998)

Variety	Origin	Systematic affiliation	Mean cold resistance at -12°C (% of surviving plants)
I. Wheat - check varieties			
Bezostaya 1	Russia	-	87.0
№ 301	Bulgaria	-	67.3
Rousalka	Bulgaria	-	46.7
San Pastore	Italy	-	22.7
II. Barley - check varieties			
Odeskiy 31	Ukraine	tetrastichum	37.0
Miraj	Rumania	tetrastichum	8.3
Hemus	Bulgaria	tetrastichum	13.0
Veslets	Bulgaria	tetrastichum	9.5
III. New genetic sources of barley with high cold resistance			
Mironovskiy 87	Ukraine	tetrastichum	56.0
Bastion	Russia	tetrastichum	69.0
Skorohod	Russia	hexastihum	65.0

Fig. 1. Cold resistance of barley at artificial freezing in chamber (-14° C). 1. cv. Mironovskiy 87 2 - cv. Hemus

Fig. 2. Cold resistance of barley at artificial freezing in chamber (-14°C). 1. cv.Skorohod; 2 - cv. Hemus

Possibilities for use in breeding. Heritability of cold resistance in F_1

Freezing to -13° C during the period 19-25 January to -14° C, when plants had high cold resistance, and during the period 8-14 February, after some decrease of hardening, allowed to determine the genetic stability of cold resistance at different states of the barley crop.

Generally, cold resistance in F_1 in reciprocal crossing of Mironovskiy 87 x Hemus and Hemus x Mironovskiy 87 is inherited in the direction of the more cold resistant parental form Mironovskiy 87. This cold resistance is very high and convincingly exceeds both mother and father components (Mironovskiy 87 with 38.0 and 43.0 %, and Hemus with 57.0 and 62.0%). Furthermore, the high cold resistance in F_1 is of stable nature on reciprocal basis both in the well hardened plants and in the plants with decreased hardening; this is an evidence that it is genetically determined (Table 2).

At these two combinations, there was no significant difference in the heritability of cold resistance in F_1 on reciprocal basis. It was established that heritability was super dominant.

Inheritance of cold resistance in F_1 in the direction of the more cold resistant parental component was registered in the cross Skorohod x Hemus, as well. Cold resistance in F_1 was very high but the mother form Skorohod was exceeded by this index with only 9 % because this parent was also highly cold resistant (Figure 2). Vice versa, the cold resistance of the parental form Hemus (possessing lower cold resistance) was significantly exceeded in F_1 - with 57.5 %. In this cross, too, it was established that the heritability of cold resistance in F_1 was super dominant.

The established instances of super dominant inheritance of cold resistance in F_1 later, at the advanced stages of breeding, allowed to develop poly-rowed winter barley varieties involving Mironovskiy 87 and Skorohod which were unique with their cold resistance (Figure 3). For the first time in Bulgarian agriculture these lines, follow-

Table 2

Inheritance of cold resistance in F1 using genetic markers with high cold resistance - Mironovskiy 87 and Skorohod

Varieties and hybrids	Surviving plants (%) after freezing at:			± D		Rate of dominance
	-14°C*	-13°C**	mean	mother	father	
Odeskiy 31	-	31	31.0	-	-	
Hemus	34	2	18.0	-	-	
Mironovskiy 87	63	11	37.0	-	-	
Skorohod	89	44	66.5	-	-	
Mironovskiy 87 x Hemus	100	60	80.0	+43.0	+62.0	+5.53
Hemus x Mironovskiy 87	100	50	75.0	+57.0	+38.0	+5.00
Skorohod x Hemus	89	62	75.5	+9.0	+57.5	+1.37

* freezing was done during the period 19-25 January at high cold resistance;

** freezing was done during the period 8-14 February at decreased cold resistance

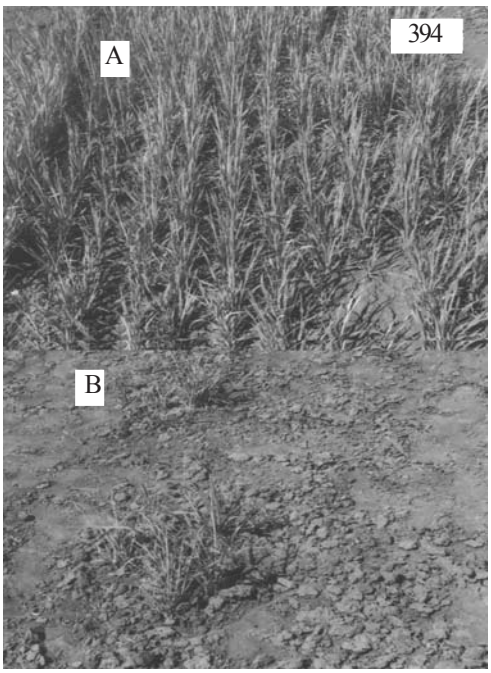

Fig. 3. New genetic source (A) with high cold resistance under field conditions during the extremely low temperatures during severe winter 2003
A - new line (General Toshevo);
B - cv. Veslets (standard variety)

ing the severe winter of 2003, demonstrated cold resistance under field conditions close to that of winter wheat No 301, which is considered a significant breeding achievement.

Conclusion

New genetic sources possessing high cold resistance were identified in breeding of winter poly-rowed barley (*Hordeum sativum* Jess., ssp. *vulgare* L.).

The inheritance of cold resistance in F_1 in the reciprocal crosses occurred in the direction of the colder resistant parental component.

Instances of super dominant inheritance of cold resistance in F_1 were registered.

Unique winter barely forms with high cold resistance were developed for the first time in Bulgarian agriculture.

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