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Results and Perspectives of Breeding by Resistance to Loose Smut in Barley

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Abstract

The article presents the results of the selection of resistance to loose smut in barley during 1978-2012 year. Indicated methods and schemes of work. There are a significant number of breeding lines that can be used as donors in the selection of resistance.

Keywords: Barley,resistance, breeding, Loose smut.

The resistance of cultivated barley varieties to infectious causal agents is an important stability factor in barley production. Vavilov (1964) accepted that breeding for plant immunity should be at the base of each breeding program. Many pathogens attack barley but only few cause serious damage. By damage and significance the loose smut occupies one of the top positions among barley diseases in Bulgaria. Despite the applied chemical protection of seed dressing, the disease reoccurs annually and causes damages to the production of barley grain. The infection is often connected to the open flowering of the predecessor plants. Reports on the lifecycle of causal agent, distribution and damage of loose smut, the methods of artificial infection and their application to evaluate varieties and breeding material were made by Geshele (1978), Ishkova (2000), Krivchenko (1984), Navushtanov (1991) Tapke (1955), Levitin (2003), Tyuterev (2005), Kavanagh (1961), Moseman (1970), Poehlman (1945). A number of countries have been working towards creating varieties resistant to loose smut. The developed designs and methods compliant with the characteristics of the pathogen gave very good results, according to Geshele (1978), Ishkova (2000), Krivchenko (1984), Navushtanov (1991) Tapke (1955), Levitin (2003), Tyuterev (2005), Kavanagh (1961), Moseman (1970), Poehlman (1945). The achieved success came as a result of using uplift resistance, connected to constant research and inclusion of new genetic sources. By the present moment worldwide 18 races have been derived and 15 resistance genes to loose smut have been identified. A number of research scientists pointed out the efficiency of the following genes: Un_3, Un_4, Un_8, Un_{13} and Un_{15} (Garkavyi, 1983, Kadyrov, 2002, Stepanovskikh, 1990, Shirokov, Paderina, 1980). The genetic set of varieties allowed to observe the population propagation in order to have the ability timely to replace genes of diminished importance in the recognized varieties with new and more efficient ones.

At the Institute of Agriculture in Karnobat, Bulgaria, breeding by resistance to loose smut is an inseparable part of the general program for creating varieties, which combines high productivity and other valuable economic traits. The aim of this article was to report the research work and achieved results in breeding by resistance to loose smut in barley and to outline the future tendencies in the breeding work by resistance.

In general the scientific research was conducted in several directions:

study of the physiological specialization of the causal agents of loose smut (Ustilago nuda);

study of the methods of infection to determine varietal resistance to loose smut (Ustilago nuda);

study of source material for breeding by resistance and inclusion of the sources of resistance in the breeding process by applying efficient breeding

methods and designs, estimation and selection of sustainable lines.

In Bulgaria targeted research on loose smut (Ustilago nuda) in barley began after 1962. The first results of race differentiation of Ustilago nuda were obtained by Mitov and Dobrev in 1967 and 1968. By use of the differential assortment of Tapke were found three race groups of the pathogen – first, second and fourth. Further research conducted by Dobrev and Navushtanov (1974, 1975) and Navushtanov, (1976, 1986, 1989, 1990) regarding the resistance of a large number of Bulgarian and introduced varieties and lines demonstrated the presence of 6 race groups. It was established that the appearance of the physiological specialization of the causal agent of loose smut in Bulgaria was mainly determined by races 1 and 4 (Mitov and Dobrev, 1972; Dobrev and Navushtanov, 1976). The other races were only seen in individual origins (Dobrev, 1974, 1975, 1987; Navushtanov, 1991). Popova (2012) presented results from research held in the period 2007-2010. Two race groups were established, analogical to the races identified by Tapke – 4 and 6. The main race in the loose smut population was race 4. The obtained results confirmed the research of other authors (Dobrev, 1970, 1972, 1987; Dobrev and Navushtanov, 1974, 1975, 1976; Mitov, 1972; Navushtanov, 1991).

Out of the tested methods of artificial infection with the causal agent of loose smut, the best results were achieved by the individual method and the method of infection with conidial suspension with the help of the vacuum apparatus (the vacuum method) (Krivchenko, 1967). The comparative testing of the two methods gave a decisive advantage to the individual (Navushtanov, 1991). In case of infection with population of the causal agent of loose smut, higher results were achieved than those obtained from infection with individual races. It provides the opportunity of faster testing of a larger number of breeding materials and variety samples.

With view to finding sources of resistance was studied the resistance of a large number of Bulgarian and introduced varieties and lines. The results from the conducted research were summarized and presented in a number of publications: Dobrev and Navushtanov (1974, 1975), Dobrev and Navushtanov (1976, 1986, 1989, 1991), Popova (2004, 2005, 2007, 2009, 2010, 2012). Collections of sustainable forms were created, including accessions from Ethiopia, Turkey, Syria, West-European selection, Russia, Bulgaria.

As sources for resistance were used donors of various origin and breeding lines from Bulgarian breeding programs, created with the participation of some of these donors. Some of the significant are: К 8728, К 6823, К 19907, PG 4437, PG 4365, PG 4440, PG 4368, PG 4433, PG 4439. Beside genes of resistance to loose smut, some of them also carry resistance to other diseases.

The first crossing at the Institute of Agriculture in Karnobat was performed in 1978. As parent plants were used varieties and breeding lines adapted to the Bulgarian conditions. Over the years alternated evaluation of resistance and phenotype with backcrossing and infection, and then again evaluation and selection, and so on. The sustainable progeny selected after two-time or three-time saturation and infection were sown on 2 m^2 each to evaluate their morphology and general condition and after that the work continued by the general breeding design.

Total for the period from 1978 to 2012 were made over 300 hybrid combinations. Both crossing and backcrossing were included. A significant number of combinations were realized with some donors – Jet, К 6823, 8728, К 19907, with the purpose of combining various genetic resistance to loose smut and valuable economic traits in one genotype. Navushtanov and Zapryanov (1990), Navushtanov and Gorastev (1990) presented summarized results on creating winter barley forms, resistant to loose smut. The method used was the interrupted backcross (Garkavyi, Kirdoglo, 1980). As mother were used No 468-multirow barley and the Alpha variety – two-row barley adapted to the Bulgarian conditions; and as father – the Jet variety, with two genes of resistance to loose smut – Un_3 and Un_6. Dependent on the saturation made and the way of cultivating certain sustainable lines of winter multirow and two-row barley. The economic traits were evaluated. Assortment of breeding materials was created (Dobrev, Navushtanov, 1972, 1975), (Navushtanov, 1989, 1990, Zapryanov et al., 1990, Vulcheva, 2005, Popova, 2004, 2005). The results obtained from the performed work over the years lead to conclude that the set goal in creating resistance to loose smut was successful. In 1996, the Perun variety, which is one of the greatest achievements of Bulgarian breeding, was

acknowledged for original and recognized for Bulgaria. It was the first time that Bulgaria created a genotype of malting barley, which combined high productivity, improved grain quality and high resistance to loose smut, conditioned by Un_3 + Un_6 (Navushtanov et al., 1997). Over the period 2001 – 2002, the variety was tested in the system of the European Brewery Convention and the obtained results showed convincingly that the Perun variety lines together with the best accessions in grain quality and high resistance to diseases (Valcheva et al., 2005).

A new direction in the breeding program for winter barley is joining the resistance to loose smut with barley stripe into one genotype. In 1996, at the Institute of Agriculture in Karnobat, were made the first crossings between varieties resistant to the two diseases - Vada, resistant to stripe disease and К- 8728, К- 6823, К- 17218, К- 19907, resistant to loose smut. The first results were summarized in a publication (Popova et al., 2004).

Many years of breeding work in the direction of resistance to loose smut led to the creation of assortment of sustainable lines of resistant winter barley. Table 1 and Table 2 present results for the economic characteristics of prospective lines. The behavior of two groups of breeding materials was studied: Group I - two-row barley, and Group II - feed barley. In the two-row group there were 10 lines and 11 feed barley, resistant to loose smut. The standards included the Obzor variety for the two-row material, and the Veslets variety for feed material. All two-row lines were from var.nutans, whereas the multirow belonged to var. pallidum.

Table 1 Ekomonic properties of perspective lines two row barley resistance to Loose smut (Ustilago nuda)

№	Vaiety,line	Variety types	Heading date	Plant heidh /cm/	Resistance to lodging / 9-1/	Morfological equality / 9-1/	1000 grain weight / g /	Grain yeld t/ha	%
1.	Обзор	er.	7-12.05	92.0	8-9	9	46.3	5.30	100
2.	ПГ 4480	n	5-8.05	106.0	8	8	44.8	5.71	107.7
3.	ПГ 4481	n	8-10.05	104.2	8	8	51.0	5.60	105.7
4.	ПГ 4458	n	8-10.05	100.5	9	7-8	47.5	5.16	97.4
5.	ПГ 4473	n	5-10.05	105.0	7-8	8	46.5	5.23	98.7
6.	ПГ 4468	n	7-12.05	114.0	7-8	7	50.5	4.63	87.4
7.	ПГ 4447	n	1-5.05	101.0	7	7	44.0	5.60	105.7
8.	ПГ 4466	n	6-10.05	99.5	9	7-8	45.8	5.20	98.1
9.	ПГ 4460	n	3-5.05	101.5	9	7-8	45.5	5.10	96.2
10.	ПГ 4463	n	5-6.06	93.5	9	8	49.5	5.32	100.4
11.	ПГ 4491	n	1-5.05	83.0	8	7-8	50.0	5.41	102.1

Table 1 shows data, which described the economic characteristics of prospective lines of two-row barley. The accessions were var. nutans. Three of the lines were of early ripening with heading date 2 to 5 days before the standard. All the other lines had the same heading date as the standard. Plant height varied from 83.0 cm to 114 cm, which appointed them into the group of average-high to high accessions. Along with this they have good lodging resistance /7-9/ rating. The data on morphological equality showed that the lines approached the requirements of UPOV- rating 7 for lines PG 4468 and PG 4447 and rating 7-8 for the other lines. As a whole the accessions had good productivity. Average for the period, the highest grain yield was observed in lines PG 4480 - 5.71 t ha-1, PG 4481- 5.60 t ha-1, PG 4447 – 5.41 t ha-1 and exceeded the standard with 2 to 7 %. The values of 1000-grain weight ranged from 44 g to 51.0 g, which determined the grain as big and suitable for malting. By complex of economic characteristics from the two-row barley stood out lines PG 4480 and PG 4481.

Table 2. Ekomonic properties of perspective lines six row barley resistance to Loose smut (Ustilago nuda)

№	Vaiety,line	Variety types	Heading date	Plant heidh /cm/	Resistance to lodging / 9-1/	Morfological equality / 9-1/	1000 grain weight / g /	Grain yeld t/ha	%
1.	Веслец	Pall.	1-8.05	99.3	9	9	39.6	550	-
2.	ПГ 4501	Pall.	1-3.05	105.0	8	8	41.5	482	88.0
3.	ПГ 4525	Pall.	10.05	104.0	8	8	39.5	461	84.0
4.	ПГ 4434	Pall.	1-5.05	106.5	8	8	37.0	554	100.7
5.	ПГ 4435	Pall.	3-5.05	105.0	9	9	37.0	506	92.0
6.	ПГ 4528	Pall.	5-6.05	101.5	9	7	39.0	576	104.7
7.	ПГ 4502	Pall.	1-3.05	95.0	9	7-8	36.0	573	104.2
8.	ПГ 4517	Pall.	8-12.05	105.5	7	7	38.8	517	94.0
9.	ПГ 4513	Pall.	5-10.05	91.5	9	8-9	40.5	628	114.2
10.	ПГ 4514	Pall.	10.05	95.0	9	9	39.5	536	97.5
11.	ПГ 4507	Pall.	3-10.05	92.5	9	7-8	35.5	550	100.0
12.	ПГ 4505	Pall.	3-10.05	96.5	9	7-8	38.5	515	93.6

Table 2 presents data on the economic characteristics of prospective lines of feed barley, which are resistant to loose smut. Data shows that a large section of the lines were of mid ripening and their heading date coincided with the standard. The heading date for three of the lines was 2 to 4 days after the standard and they were identified with late ripening. The height of the studied lines were significantly greater and ranged from 91.5 cm to 110 cm. The lodging resistance in 7 lines was at the level of Veslets, and only line PG 4517 had the rating of 7. Accessions PG 4435, PG 4513, PG 4519 had high morphological equality

– rating 8-9. The data presented on 1000-grain weight showed that it was within 35.5 g and 41.5 g and was at the level of the standard Veslets. The average yield from the studied lines ranged from 4.61 t ha-1 to 6.28 t ha-1, and for the standard Veslets it was 5.50 t ha-1. Two of the lines had lower productivity than the standard. Four lines yielded close to the standard Veslets, namely PG 4435, PG 4517, PG 4513, PG 4505. Two of the lines were at the standard level: PG 4434 and PG 4507. Three of the lines exceeded the standard from 4.4 to 14.0. The highly productive lines were PG 4528, PG 4502, PG 4513, whose yield was 5.76, 5.73 and 6.28 t ha-1, respectively. Breeding line PG 4513 was characterized as material with very good economic characteristics.

Conclusion

As a result of more than 30 years of targeted scientific research in breeding by resistance to loose smut was achieved significant progress, demonstrated by study of source forms, suitable donors, evaluation methods and breeding designs. Prospective lines of winter barley were created, and there was achieved a combination of resistance and a number of valuable biological and economic characteristics. These lines are new genetic plasm and can be successfully used in both general breeding and other directions. The Perun variety was the first Bulgarian winter malting barley variety, which combined resistance to loose smut and valuable agrobiological properties. At the same time over the last years were studied new introduced materials of various genetic resistance, which enriched the assortment of immune selection donors.

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