Study of samples of spring barley from the collection of the All-Russian institute of crop production for resistance to biotic stress

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Abstract. Spring barley in Eastern Siberia occupies an important place among the main grain crops and is grown mainly for fodder purposes. Its grain can also be used in bakery, confectionery, pharmaceutical and other industries. In addition, barley is the main raw material for brewing. One of the reasons that have a significant impact on the formation of the yield and technological qualities of barley is the high susceptibility of the crop to phytopathogenic microflora, the strong development of which leads to their decrease. Barley is the most affected crop of the cereal group. The most common diseases are root rot, represented mainly by pathogens of the fusarium - helminthosporium complex. Fungi of the genus Bipolaris were identified in the forest-steppe zone, in the subtaiga zone - species of the genus Fusarium. Both are capable of infecting almost all underground and aboveground plant organs. According to the long-term data, root rot annually reduces grain yield by 20 - 23%. Samples of barley with resistance to damage by dark brown and striped barley spotting (7 points, reaction type - R) were identified; Heritage (USA), Condor, AC Albright (Canada), Malva (Latvia), Wash, Symphony (Ukraine), Viner (Kirov region), Pervocelinnik (Orenburg region), Vorsinsky 2 (Altai region) and Zauralsky 1 (Tyumen region).

1. Introduction
Barley is a universal crop of versatile use, which is of great fodder, food, technical and agrotechnical importance. This is one of the most important grain fodder crops for farm animals, since barley grain is much better balanced than other cereals in amino acid composition, primarily in lysine content. Only 20% of lysine are missing in barley protein for full animal feeding, while in wheat protein - 42-43% [1, 2]. Also, barley grain is a source of valuable polysaccharides (β-glucans), which are used in functional nutrition and have a positive effect on human health [3]. In this regard, in order to increase the gross harvest of barley with improved indicators of grain quality, it is necessary to introduce varieties resistant to diseases and pests [4]. To solve this problem, it is necessary to study the source material of barley and identify the most tolerant sources for breeding.

The purpose of the work was a comprehensive assessment of barley samples from the VIR collection for resistance to the main pathogens and pests.
2. Research methodology

238 barley samples from the collection of the Federal Research Center “All-Russian Institute of Plant Genetic Resources named after N.I. Vavilov” (VIR) were the objects of study, 110 of which were of foreign origin, the rest were representatives of domestic selection.

The studies were carried out in 2018–2020, on the experimental fields of the Krasnoyarsk Scientific Research Institute of Agriculture (KrasNIISH FRC KSC SB RAS), located in the forest-steppe zone of Eastern Siberia (figure 1). The soil of the experimental site is represented by ordinary thin chernozem, characterized by agrochemical indicators: humus content (according to Tyurin) - 6.30%, N-N\text{O}_3 (ionometric express method) - 14.2 mg / kg soil, P_2\text{O}_5 (according to Chirikov) - 18.50 mg / 100 g of soil, K_2\text{O} (according to Chirikov) - 13.10 mg / 100 g soil; the reaction of the soil solution is close to neutral (pH - 6.2). The predecessor is pure steam. Plot area - 1.8 m\textsuperscript{2}. Sowing was carried out at the time optimal for the culture, in the second decade of May; the samples were harvested as they ripen. Weather conditions in the Krasnoyarsk forest-steppe (v. Minino) Figure 1. during the study years were contrasting: 2019 and 2020 - sufficiently wet (GTK - 1.22 and 1.78); 2018 is a dry year (GTK - 0.75).

In the field, the length of the growing season of plants was noted. In laboratory conditions, the analysis of the elements of the structure of the yield was carried out according to the VIR method [5].

The study of the barley resistance to dark brown spotting on the natural background was carried out according to the scale of quality accounting [6]. This scale takes into account the type of reaction and the size of the spots on the top three leaves of plants in the early to medium waxy ripeness phase. Resistance (R) is characterized by small necrosis in the absence or poorly developed marginal chlorosis. With moderate resistance (MR), medium-sized necrotic spots with no necrosis or very mild necrosis are observed. Moderate susceptibility (MS) manifests as medium to large elliptical necrosis with marginal chlorosis. The susceptibility reaction (S) is characterized by large, elongated necrosis with extensively developed chlorosis.

A degree of plant damage by striped spotting was determined by the percentage of the area covered with spots [7].

The assessment for pest resistance was carried out according to the VIR method, where:

- 9 points - very high resistance - damage to no more than 5% of plants;
In order to create a provocative background to increase the number of the pest, crops were placed near stubble and forest belts with shrubby vegetation, where beetles of the striped flea beetle overwintered.

The data were statistically processed using standard Microsoft Excel computer programs. The significance of differences in the results was assessed at $p \leq 0.05$.

3. Research results

In the course of the research, valuable samples that combine grain size due to the high mass of 1000 grains with increased productivity have been highlighted: Mayak (Krasnoyarsk Territory) and Zauralsky 1 (Tyumen Region). The early maturing and high-yielding specimens - Duplex C.I. 2433 (USA), BVP-2D-1 (Canada), Voll (Norway), Olbram (Czech Republic), Tarsky 3 (Omsk Region), Zolotnik (Altai Territory), Zauralsky 1 (Tyumen Region), Kazminsky (Khabarovsk Territory), Adamovsky 1, Miar (Orenburg region) and Omsk 13709 (Omsk region). In 2018-2020, record yield (514-667 g / m2) was formed by BVP-2D-1 (Canada), Lenetan (USA), Phoenix (Ukraine), Vodar (Belarus), Vorsinsky 2 (Altai Territory), Kazminsky (Khabarovsk Region), Zauralsky 1 (Tyumen Region), Memory of Chepelev (Sverdlovsk Region), Grace (Germany).

The results of the studies carried out to assess the breeding value of individual elements of productivity and yield in general made it possible to identify samples with a complex of economically valuable traits that we recommended for breeding use in the East Siberian region. So, with the participation of the highly productive variety Abalak (a joint variety of scientific institutions of the Krasnoyarsk Territory and the Tyumen Region), we had previously obtained valuable breeding material, from which promising breeding lines were marked in 2019. They include: D-56-7475 (Abalak × T-86-7306), D-59-7505 (Abalak × U-29-3617) and D-55-7455 (Abalak × k-22092), which significantly exceeded the yield of the standard grade Acha by 5.4 ... 7.8 c / ha. In recent years, the inclusion of such varieties into hybridization as Tarskiy 3 (Omsk oblast), Talan (Novosibirsk oblast), Bagrets, Kalita (Sverdlovsk oblast), Nutans 302 (Samara oblast), Adamovskii 1 (Orenburg oblast), Belgorodets (Belgorod region), Malva (Latvia), AC Albright, Diamond and CDC Mc Guire (Canada) made it possible to obtain a new, more productive breeding material. With their participation, more than 100 new hybrid combinations were created. Promising breeding lines with high rates of productivity, ecological plasticity and stability were selected from them.

Among grain crops, barley is less resistant to lodging, especially when placed on high agrotechnical backgrounds, as well as after heavy rainfalls accompanied by squally winds. Lodging of barley crops limits obtaining high and stable yields. Harvest losses are very significant due to difficulties in harvesting. The shortfall in grain during lodging can reach 15-40% of the yield [8].

The inconstancy of the manifestation of lodging makes it difficult to assess the resistance of plants in field conditions, therefore, various provocative backgrounds and experimental lodging are used. We have assessed the barley collection for its resistance to lodging in the field. In 2020, due to unfavorable weather conditions, its strong manifestation was noted - up to 1-3 points. In general, in the years of field tests, the resistance of specimens to lodging varied from low to high (1-9 points). Based on the results of the assessment, 10 barley samples were identified, with high resistance to lodging (8.3-9.0 points) in combination with increased productivity. In this respect, the following varieties deserve attention: Codac, Etienne, Diamond, AC Albright (Canada), Vaughn C.I. 11367 (USA), Bagrets (Sverdlovsk region), Ubagan (Chelyabinsk region), Talan and Tanay (Novosibirsk region) and Abalak. The high resistance to lodging of these samples was also confirmed against an artificial background with the introduction of an increased dose of nitrogen (N120) into the soil.
The protein content in grain as an indicator of grain quality depends to a large extent on the genetic affiliation of the variety, weather conditions and the level of agricultural technology. The climatic conditions of Eastern Siberia are more suitable for growing feed barley with a high protein content. Increased accumulation of protein in grain (14.07-14.73%) of two-row filmy barley was observed in samples Cirstin (Germany), 18/7 (Dagestan), Zolotnik (Altai Territory), as well as in naked varieties - NS GL1 (Yugoslavia), Omsk Golozerny 1 (Omsk Region) and Nudum 95 (Chelyabinsk Region) with the indicator of the standard Acha variety - 13.00% and CV = 8.7%. Two-row samples were identified as sources of high gross protein collection per unit area (79.9-89.1 g/m²) - Chelyabinsk 2, Ubagan (Chelyabinsk region), Talan, Tanay, Biom (Novosibirsk region) and six-row type varieties - Codac, Etienne (Canada) and Kolchan (Altai Territory). The nature of the grain depends on the size, shape and uniformity. A high natural weight of barley indicates good drying and a large amount of extractives. This indicator correlates with protein content, extractability, filminess and 1000 grain weight. It also characterizes the possibility of using grain for cereals and other food products. The high grain nature was noted in the varieties AC Albright - 673 g/1 (Canada), Lovisa - 669 g/1 (Finland), Sjak - 668 g/1 (Sweden), Tanay - 732 g/1 (Novosibirsk region) and Omsk golozerny 1 - 857 g/1 (Omsk region).

It should be noted that in the process of breeding for immunity, one should not underestimate the assessment of the resistance of breeding material in natural conditions, which, according to A.A. Gryaznov [9] are approaching weak backgrounds of artificial infection. Weak backgrounds allow you to identify samples with horizontal stability. However, in this case, (A.I. Shirokov and K.M. Zykin [10]), one should not forget about the modification variability.

In the field conditions of the Krasnoyarsk forest-steppe, an outbreak of leafy fungal diseases was noted. Fungi of genus Bipolaris and Fusarium were the most common among them. They manifested in the form of root rot, lower internodes, brown leaf spotting, black embryo of grain [11,12,13]. In this regard, an assessment was made for the resistance to damage of barley by dark brown spotting (Drechslera sorokiniana). The highest resistance (7 points, reaction type - R) is characterized by Heritage (USA), Condor, AC Albright (Canada), Malva (Latvia), Wash, Symphony (Ukraine), Viner (Kirov region), Pervotselinnik (Orenburg region) , Vorsinsky 2 (Altai Territory) and Zauralsky 1 (Tyumen Region).

On average, over three years, a lesser infestation of barley by striped spotting (Pyrenophora graminea Ito & Kuribayashi) was observed in samples NS GL 1 (Yugoslavia), Phoenix (Ukraine), Ilek 16 (Kazakhstan), and Ubagan (Chelyabinsk oblast).

In the field, the samples were evaluated for resistance to the striped bread flea. The striped bread fleas (Phyllotreta vittula Redt.) most severely damages crops such as spring wheat, and to a lesser extent barley and oats. The oblong, black beetle about 2 mm long, shards with a yellow stripe. Eggs are pale yellow, 0.5 mm long. Larvae are up to 3.5 mm, white, cylindrical, covered with sparse hairs. Pupae are darker than larvae. It develops in one generation. In spring, beetles appear very early on crops and are most active at temperatures of 17-20 °C. Eggs are laid in May–June in the soil to a depth of 10-30 mm, 15 days later they hatch into larvae that feed on humus and roots of cereals. In mid-summer, the larvae reach full maturity and pupate; in July, beetles of a new generation emerge, concentrating on ears of corn and also on wild cereals. After harvesting, the beetles move to areas with woody or shrub vegetation, where they remain for the winter [14].

In 2019, the damage to barley by the striped bread flea increased due to the dry period of seedling-tillering. Samples, resistant to the striped bread flea with a maximum score of 7-9 points were not found among those studied in the collection. However, individual samples showed an average resistance of 5 points. These include Duplex C.I 2433 (USA), Mayak, Emelya (Krasnoyarsk Territory) and Abalak (a joint variety of institutions of the Krasnoyarsk Territory and Tyumen). At the same time, in 2019, compared to 2018, the number of samples with low resistance and damage to the number of plants of more than 40% (1 point) was twice as high, which is associated with a high number of pests and unfavorable weather conditions for plants in the period after germination. In 2020, the share of samples with very high and high resistance (7-9 points) was 61.0%. Standard varieties Acha and Sobolek had different resistance to the pest (from 1 point in 2019 to 7 points in 2020). For all the years of study, the
least damaged variety was Abalak, which is characterized by the high selection value in terms of the yield [15].

4. Conclusion
As a result of the studies carried out, it was found that the pathogens of helminthosporiosis and fusarium are the most harmful, they inhibit the growth and development of seedlings, reduce the length, number and weight of roots. The disease on plants with various symptoms manifests throughout the growing season - from germination to harvesting.

Analysis of the data shows that resistance to individual leaf-stem infections is specific and is inherited independently: a variety that is highly resistant to one infection may be susceptible to another. Thus, the resistance to biotic stress is a high effective method for suppressing the economic threshold of leaf-stem infections in the spring barley.

Samples of barley with resistance to damage by dark brown and striped barley spotting were identified. As a result of the research, the resistance of the Abalak barley variety to damage by the bread striped flea was established.

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