

Use of sources of resistance to smut in the breeding of spring barley

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Abstract. The paper aims to create and study the complex of traits of the multi-row forage barley variety Krasnoyarsky 91. The selection sample K-8-19 and the Acha variety were used as parent forms. The variety has been included in the state register of breeding achievements since 2017 in the East Siberian (11) region. Recommended for cultivation in the Krasnoyarsk Territory, the Republic of Khakassia, Tyva, Buryatia. Multirow, a type of pallidum. The duration of the growing season is medium-late. On average, over three years (2012-2014) in the competitive test, the grain yield of the variety ranged from 26.3 to 40.5 c/ha, with an average yield of 32.1 c/ha. The advantage over the Acha variety was 4.0 c/ha, and over the Sobolek variety 6.3 c/ha. The variety has a high yield of green mass. When harvesting for green fodder, the advantage in terms of green mass yield in terms of dry matter ranged from 0.6 to 20 c/ha. Krasnoyarsk 91 is resistant to fungal diseases. The variety is recommended for use for feed purposes.

1 Introduction

Barley has a wide variety of forms; it is the most early-ripening and flexible crop. Due to its good adaptability to environmental conditions, barley is widely used throughout all continents of the world [1]. In terms of acreage, it ranks fourth in the world (after wheat, rice and corn) and second in our country (after wheat) [2].

One of the key factors in enhancing the profitability of livestock production is the cultivation and efficient utilization of grain feed crops. Barley plays a significant role in ensuring the success of livestock production. It is used not only as a grain feed crop but also as a raw material for the production of haylage and grain haylage, which are essential components of livestock feed.

Barley grain contains a lot of protein, starch and is a good feed for all types of animals. It is especially widely used in pig farming. Barley protein contains the entire set of essential amino acids, including the especially valuable lysine and tryptophan [4]. About 60% of the barley produced in the Russian Federation is used for feed purposes, as it is a good animal feed containing essential nutrients [5].

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The green mass of barley is used for feed, hay, haylage, grass meal, and for the preparation of concentrated feed in the form of briquettes and granules. 1 kg of green mass contains 0.17-0.19 units, 20-22 g of digestible protein, 30-40 mg of carotene [6]. In the Krasnoyarsk Territory, barley is widely used for laying grain haylage. It is used either in pure form or mixed with other legumes and grains. In the forest-steppe of the Krasnoyarsk Territory, the most effective was the use of a mixture of peas + oats + barley + wheat in the ratio 10:30:30:30, which led to a significant increase in profitability [7].

Selection plays a significant role in increasing yields. The creation and introduction into production of highly productive and at the same time stress-resistant varieties makes it possible to increase and stabilize feed production. Sources of resistance isolated from the world collection are usually poorly adapted to regional climatic conditions and this complicates their direct use in the breeding process. The task was set to create our own sources of resistance to barley smut based on local breeding material. For 1990-2003 At the Krasnoyarsk Research Institute of Agriculture, more than 1000 samples of a barley collection were studied for resistance to smut and 58 sources of resistance were identified.

The variety has a significant impact not only on yield, but also on the feeding value of agrocenoses [8]. For use in green fodder and the production of haylage and grain haylage, the most effective is the use of multi-row varieties.

The purpose of the research is to create and study a variety of multi-row barley for fodder use based on a complex of biological and economic characteristics.

2 Materials and methods

The experimental part of the research was carried out on experimental fields and in laboratories of the Krasnoyarsk Research Institute of Agriculture. The experiments were laid in fallow, with a seeding rate of 5 million germinating grains per hectare. The humus content in the soil of the experimental plot is 4.3-5.2%, K₂O – 14.8-17.9 mg/100 g of soil, P₂O₅ – 17.6-25.6 mg/100 g of soil.

For harvesting for grain, the accounting area was 9 m², for green mass - 1 m². Repeat four times. The grain fodder standard is the Acha variety, the Sobolek variety is the standard when taking into account green mass. The article uses the results for 2015-2019. Eastern Siberian branches of the Federal State Budgetary Institution State Sort Commission.

3 Results and discussion

The Krasnoyarsk 91 variety was created at the Krasnoyarsk Research Institute of Agriculture through intraspecific hybridization followed by individual selection. The crossing of the selection sample K-8-19 with the Acha variety was carried out in 2005, and the selection of an elite plant was carried out in 2008.

The pallidum variety belongs to multi-row barley. The variety is medium late, the duration of the growing season is 77-83 days. The ripening of the variety occurs later than the Acha variety by 7-10 days and later than the Sobolek variety by 4-8 days. The duration of the growing season is increased due to the period of seedling heading.

In 2012-2014 the variety Krasnoyarsky 91 was studied in a competitive variety trial in the department for evaluating breeding material. On average, over three years (2012-2014), the grain yield of the variety ranged from 26.3 to 40.5 c/ha, with an average yield of 32.1 c/ha. The advantage over the Acha variety was 4.0 c/ha, and over the Sobolek variety – 6.3 c/ha (Table 1).

Table 1. Productivity of the Krasnoyarsky 91 variety in the competitive variety testing nursery (2012-2014).

Variety	Vegetation period, days	Yield, c/ha			
		2012	2013	2014	average
Acha, standard	75	35.8	26.3	22.2	28.1
Sobolek, standard	77	33.2	24.1	20.0	25.8
Krasnoyarsky 91	83	40.5	29.6	26.3	32.1
HCP ₀₅		2.8	2.9	2.6	

The grain productivity of the crop as a whole is determined by the complex interaction of the elements of the crop structure. It is determined by three components: the number of productive ears per unit area, the number of grains in the ear and grain size, expressed through the mass of 1000 grains.

In terms of weight of 1000 grains (35-39 g), Krasnoyarsky 91 is inferior to the two-row Acha variety by 5-7 grams. With the multi-row Sobolek variety, the weight of 1000 grains is approximately the same (Table 2). In terms of grain content of the ear, it surpasses the Acha variety by an average of 13.0 and Sobolek by 7.0 grains. Due to the low tillering coefficient, the multi-row varieties Krasnoyarsky 91 and Sobolek are inferior to the two-row variety Acha in terms of productive stem density. Moreover, in this indicator, Krasnoyarsk 91 is superior to Sobolek.

Table 2. Comparative assessment of barley varieties by elements of crop structure. (2012-2014).

Variety	Number of grains in an ear, pcs.		Weight of 1000 grains, g.	Number of productive stems, pcs/m ²		
	range of variability	average	range of variability	average	range of variability	average
Acha, standard	13 - 16	15	39.6 – 46.3	43.4	314 - 379	330
Sobolek, standard	15 - 29	21	35.2 – 39.4	38.2	232 - 286	252
Krasnoyarsky 91	17 - 34	28	34.9 – 38.8	37.2	264 - 312	288

In years with excessive moisture and a high agricultural background, the Acha variety is inferior in resistance to lodging by up to one point. This is due to the greater height of the plant and the heavy multi-row ear. With the Sobolek variety, resistance to lodging is on the same level. Resistance to drought in the first half of the growing season is high, during the grain filling period it is average.

An increase in grain yield is usually accompanied by a significant decrease in the protein content of the grain. For forage varieties this indicator is of great importance. The protein content in Krasnoyarsk grain is 91 from 9-13%. In terms of protein content, it is inferior to the Acha variety by about one percent, but due to its high yield, it is superior in protein yield per hectare. With the Sobolek variety, the protein content is at the same level.

Resistance to fungal diseases is one of the main characteristics of the variety. The maximum damage to loose smut on an artificial infectious background in Krasnoyarsk 91 was 13.6%, in the Sobolek variety - 28.9%, in the Acha variety - 72.1%. The variety is resistant to stone smut. It was weakly affected by stem rust and dark brown spotting, and moderately affected by root rot.

Krasnoyarsky 91 confirmed its high productivity in the variety plots of Eastern Siberia. The maximum yield of 80.1 c/ha was obtained in 2018 at the Uyarsky variety site in the Krasnoyarsk Territory. Since 2017, it has been recommended for cultivation in the

Krasnoyarsk Territory, the Republics of Khakassia, Tyva and Buryatia. In the Krasnoyarsk Territory, the variety is recommended for cultivation in zones VI (forest-steppe of the Chulym region) and VIII (steppe of the foothills on ordinary and southern chernozems).

For 2015 - 2019 the advantage compared to the Acha standard ranged from 5.6 c/ha (Nazarovo State Institution) to 8.1 c/ha (Krasnoturansky State Institution) (Table 3). Only in the Uzhursky variety plot Krasnoyarsky 91 was inferior to the standard by 1.1 c/ha. Since 2018, testing of the Sobolek variety at variety plots in the Krasnoyarsk Territory has been discontinued. For 2015-2017 the advantage compared to the forage variety Sobolek ranged from 2.0 c/ha (Uzhursky GSU) to 16.8 c/ha (Krasnoturansky GSU). Since 2018, testing of the Sobolek variety at variety plots in the Krasnoyarsk Territory for grain has been discontinued.

Table 3. Grain productivity of Krasnoyarsky 91 barley in the variety plots of the Krasnoyarsk Territory for continuous sowing crops (2015-2019).

Variety	Yield, c/ha						
	2015	2016	2017	2018	2019	average	deviation
Nazarovo GSU							
Acha, standard	43.5	30.4	48.6	26.0	50.9	39.9	-
Krasnoyarsky 91	43.9	32.2	47.2	44.7	59.6	45.5	5.6
Sobolek	44.2	21.7	46.1	-	-	37.3	-3.5
Novoselovo GSU							
Acha, standard	26.5	32.6	27.6	38.9	43.6	33.8	-
Krasnoyarsky 91	28.9	38.4	33.8	56.1	41.7	39.8	6.0
Sobolek	23.1	25.2	-	-	-	24.2	-5.4
Minusinsk GSU							
Acha, standard	27.3	58.8	37.8	30.9	43.0	39.6	-
Krasnoyarsky 91	32.0	62.9	45.9	38.0	52.7	46.3	6.7
Sobolek	24.4	47.8	25.6	-	-	32.6	-8.4
Krasnoturansky GSU							
Acha, standard	22.1	42.1	19.5	36.3	31.3	30.3	-
Krasnoyarsky 91	38.8	49.9	31.2	47.2	44.6	42.4	8.1
Sobolek	22.7	26.6	20.4	-	-	23.2	-5.7

Testing of the Krasnoyarsky 91 variety on variety plots in other regions of Eastern Siberia showed the high productivity of the variety. At a number of variety plots, the yield increase for 2015-2018 was ranged from 2.6 to 7.3 c/ha compared to standard varieties (Table 4). The variety has high ecological plasticity. It shows good results both in the dry steppe zone of the Republic of Buryatia, Khakassia and Tyva, and in the forest-steppe zone of the Krasnoyarsk Territory and Irkutsk region, which is well supplied with moisture.

Table 4. Results of testing the Krasnoyarsky 91 barley variety for grain productivity at variety plots in Eastern Siberia (2015-2018).

Variety plot	Region	Yield, c/ha		Deviation
		Krasnoyarsky 91	Standard	
Zakamensky	The Republic of Buryatia	15.2	Odon – 12.6	2.6
Krasnochikoisky	Transbaikal region	31.7	Anna – 29.1	2.6
Irkutsk	Irkutsk region	39.2	Acha – 36.3	2.9

Kuitunsky	Irkutsk region	41.7	Acha – 38.8	2.9
Shilkinsky	Transbaikal region	20.5	Anna – 17.2	3.3
Dzhidinsky	The Republic of Buryatia	24.0	Odon – 20.5	3.5
Bichursky	The Republic of Buryatia	18.5	Odon – 14.8	3.7
Shirinsky	The Republic of Khakassia	30.4	Acha – 24.5	5.9
Pius-Khemsy	Tyva Republic	27.2	Acha – 19.9	7.3

One of the main advantages of the variety is the high yield of green mass. Over three years of competitive variety testing at the Krasnoyarsk Research Institute of Agriculture (2013-2015), with a green mass yield of 204 c/ha, it surpassed the Acha variety by 65 c/ha and the Sobolek variety by 54 c/ha. The advantage was due to the greater height of the plant and higher foliage. It should be noted that although Krasnoyarsk 91 has serrated awns, they are much softer than those of the Acha and Biom varieties; the serrations are small and are located only at the end of the awn.

At a number of variety sites in the Krasnoyarsk Territory, Khakassia and Tyva in 2015-2017, tested the variety for green fodder in comparison with the fodder variety Sobolek. The increase in green mass yield in terms of dry matter ranged from 0.6 to 20 c/ha (Table 5).

Table 5. Results of testing the Krasnoyarsky 91 barley variety for green fodder at variety plots in the Krasnoyarsk Territory, Khakassia and Tyva (2015-2017).

Variety plot	Dry matter yield, c/ha								Deviation
	Krasnoyarsky 91				Sobolek				
	2015	2016	2017	average	2015	2016	2017	average	
Minusinsky	88.1	51.4	53.5	64.3	61.7	38.2	33.1	44.3	20.0
Nazarovsky	25.1	55.1	50.5	43.6	25.7	42.9	46.1	38.2	5.4
Krasnoturansky	44.4	67.7	51.5	54.5	47.5	68.6	45.6	53.9	0.6
Shirinsky	27.3	94.3	47.5	56.4	28.6	99.4	34.8	54.3	2.1
Pius-Khemsy	33.6	89.0	35.5	52.7	34.2	65.0	31.6	52.7	9.1

At the Minusinsk variety site, the dry matter yield was 64.3 c/ha, 20 c/ha higher than the Sobolek standard. At Nazarovsky the increase was 5.4 c/ha, at Krasnoturanskoye 0.6 c/ha. In the Shirinsky variety plot of the Republic of Khakassia, with a dry matter yield from 27.3 c/ha to 94.3 c/ha, the average increase was 2.1 c/ha. In the Piy-Khemsy variety plot of the Republic of Tyva, the average increase was 9.1 c/ha. The maximum yield of green mass in terms of dry matter of 94.3 c/ha was obtained in 2016 at the Shirinsky variety plot of the Republic of Khakassia.

The effectiveness of using the Krasnoyarsk 91 variety for both grain and green fodder has been confirmed in experiments by the Department of Plant Growing, Breeding and Seed Growing of Krasnoyarsk State Agrarian University. The variety took second place out of the eight varieties studied in terms of the yield of feed units when harvested for grain, losing to the Biom variety due to its lower protein content. When used twice (mowing for green mass in the boot phase followed by harvesting for grain), the yield of feed units was second only to the Zhikhar variety [9].

For the Krasnoyarsky 91 variety, copyright certificate No. 67210 and patent No. 9160 dated July 11, 2017 were received. Patent holder: Federal State Budgetary Institution Federal Research Center "Krasnoyarsk Scientific Center SB RAS".

4 Conclusion

In the wheat breeding laboratory of the Krasnoyarsk Research Institute of Agriculture, a new variety of spring barley of the fodder type, Krasnoyarsk 91, has been created, adapted to the diverse natural and climatic conditions of Eastern Siberia. Since 2017, it has been recommended for cultivation in the Krasnoyarsk Territory, the Republics of Khakassia, Tyva and Buryatia. In the recommended cultivation regions, the variety is superior to standard varieties in terms of grain productivity and green mass yield. The use of the variety in feed production will increase the profitability of livestock products.

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