Characteristics of the Western European ecological group barley varieties in the North-Western region of the Russian Federation

Olga Kovaleva and *Kseniia* Lukina*

Federal Research Center N. I. Vavilov All-Russian Institute of Plant Genetic Resources (VIR), 191031 Bolshaya Morskaya st., 42-44, St. Petersburg, Russia

Abstract. In the North-West region, spring barley is the main grain fodder crop. The variety is an effective and most affordable means of increasing the harvest and quality of the grain. The studying selection material for breeding ensures success in the creation of new varieties. European varieties are characterized by resistance to powdery mildew, which is a limiting factor of breeding in the North-West region. This work aimed to find new sources of agrobiological valuable traits. In 2016-2018, which differed in weather conditions, 32 varieties of spring barley were studied on the field of the Pushkin Laboratory of VIR. As a result of studying a set of samples of the Western European ecological group, according to the main agrobiological valuable traits sources for breeding in the North-West region were identified: early maturing, semi-dwarf, large-grain variety – "Brucefield" (к-31555, *parallelum*, Germany); semi-dwarf, large-grain variety – "Brennus" (к-31331, *nutans*, France); middle-maturity, high-yielding, large-grain, semi-dwarf, resistant to lodging, with an adaptation coefficient more than 1 – "Niagara" (к-31334, *nutans*, France), "Tocada" (к-31341, *deficiens*, Germany), "Juhata" (к-31346, *nutans*, Germany), "KWS Alciana" (к-31348, *nutans*, Germany).

1 Introduction

Barley is the main grain-fodder crop of the North-West region. In the Leningrad region, barley occupies 63% of the grain wedge [1]. The creation of new varieties is the most important resource for the development of agriculture. Increasing the quantity and quality of the yield depends on the properties of the variety.

Correctly select material for breeding ensures success in the creation of new varieties. The world collection of VIR includes more than 18 thousand barley samples. It is the main source of initial material for breeding. Recently, varieties of foreign selection occupy 40% of the economic varieties in Russia [2]. These varieties belong to the Western European agroecological group and are mainly represented by varieties from Germany and France. Varieties of European selection are characterized by resistance to powdery mildew,

* Corresponding author: k.lukina@vir.nw.ru

provided by the presence of the *mlo11* gene, which is one of the main factors of the advantage of these varieties over varieties of Russian selection [3].

At present, the gene pool of the VIR collection has been replenished with a large number of new Western European varieties. The cultivars are obtained from the European Union breeding firms. In order to identify sources and donors of valuable traits to the main breeding directions, it is necessary to study this material extensively for certain soil and climatic conditions. In this regard, the study of the West European ecological group materials in the conditions of the North-Western Russia region is actually. This work aims to study new barley varieties from the West European ecological group of the world VIR collection in the conditions of the North-West region and identify the sources for breeding.

2 Materials and methods

32 varieties of spring barley obtained from European breeding institutions were studied at Pushkin (Pushkin and Pavlovsk laboratories of VIR) for three years (2016-2018). All varieties are two-rowed and are represented by varieties of *nutans* and *deficiens*, and only one six-row variety – "Brucefield" (*parallelum*).

According with the Guidelines for the study of the world collection of barley and oats [4] the study was carried out. The zoned, mid-ripening and widely cultivated variety "Suzdalets" (к-30314, *nutans*, Moscow district), the previously zoned, mid-ripening and adaptive cultivar "Krinichniy" (к-27605, *nutans,* Belarus) and the six-row zoned and mid-early cultivar "Belogorskiy" (к-22089, *pallidum, rikotense*, Leningrad district) and early maturity cultivar "Potra" (к-26209, *parallelum*, Finland) were used as standards. The weather conditions during the growing season varied significantly (Table 1).

Table 1. Meteorological conditions Pushkin 2016-2018.

Amount of precipitation, mm				
Month	**2016**	**2017**	**2018**	**Average long-term values**
May	17,8	13,4	13,7	44,1
June	63,8	68,5	23,1	65,2
July	174,2	122,5	95,2	75,6
August	174,3	147,6	61,6	80,3
Average daily air temperature, °C				
Month	**2016**	**2017**	**2018**	**Average long-term values**
May	17,5	9,4	15,1	10,85
June	18	13,6	16,2	15,55
July	19,6	16,5	20,1	18,3
August	18,2	17,4	19,2	16,45

In 2016, in May, the average temperature was 17.5°C, it was 7°C higher than usual, precipitation was less than normal. In June, the weather conditions did not differ significantly from the average for summer indicators, it was warm and there was enough rainfall for good plant development. July and August were characterized by an excess of rainfall, it was led to the formation of additional tillerings. Weather conditions were favorable for the high yield due to productive tillerings.

During the growing season of 2017, weather conditions significantly differed from the average long-term indicators. Average temperatures in May, June and July were below normal. In May, the precipitation was insufficient in 3 times lower than the norm, in June the monthly norm of precipitation fell, July and August were characterized by excessive amounts of precipitation. Lack of heat at the beginning and in the middle of the growing

season promoted later heading; the growing season was on average 10 days longer. In general, the weather conditions were quite favorable for the growth and development of barley plants, which led to a high yield.

In 2018 the weather conditions were significantly different from the long-term average. Average temperatures were higher than the average multiyear norm. In May and June, precipitation fell 3 times less than the norm. At the beginning of July, the monthly norm of precipitation fell, and later, until the end of the growing season, a drought was observed. The lack of moisture in the soil during the seedling-heading period led to a reduced tillering of barley plants, an increased temperature contributed to the formation of sterility of pollen grains, which led to overgrowth. The lack of rain during the ripening period led to the puffiness of the grain and was reflected in the yield and weight of 1000 grains.

The results were carried out by methods of variance, correlation analyzes according to B.A. Dospekhov and using Microsoft Excel [5]. The coefficient of adaptability was calculated by the method of Zhivodkov L. A. [6].

3 Results and Discussions

The creation of early ripening varieties of barley is the most important task for regions of Russia with a short growing season. The introduction of such varieties in the North and North-West regions will ensure the harvesting of barley in the optimal agrotechnical terms. The use of early maturity varieties of barley will allow to store up grain silage and crimped grain in favorable conditions. It will lead to guaranteed obtaining seeds with high sowing qualities. In areas with high temperatures and drought, the use of early maturity varieties with active growth in the first phases of the growing season (seedling-tillering) allows to escaping from summer droughts. Such varieties form a root system quickly, use the reserves of spring moisture and suffer the arid conditions better.

The main direction of breeding in the North-West of Russia is early maturity. According to the results samples maturing earlier than the early maturity standard "Potra" (68 days) were not found. Only one accession – "Brucefield" (к-31555, *parallelum*, Germany) was mature at the level of "Potra". 2 varieties: "Niagara" (к-31334, *nutans,* France), "Power" (к-31353, *nutans*, Germany) were maturity as the medium early standard "Belogorskiy" (75 days). The rest of the samples were assigned to the mid-maturity group (more than 75 days) (Figure 1).

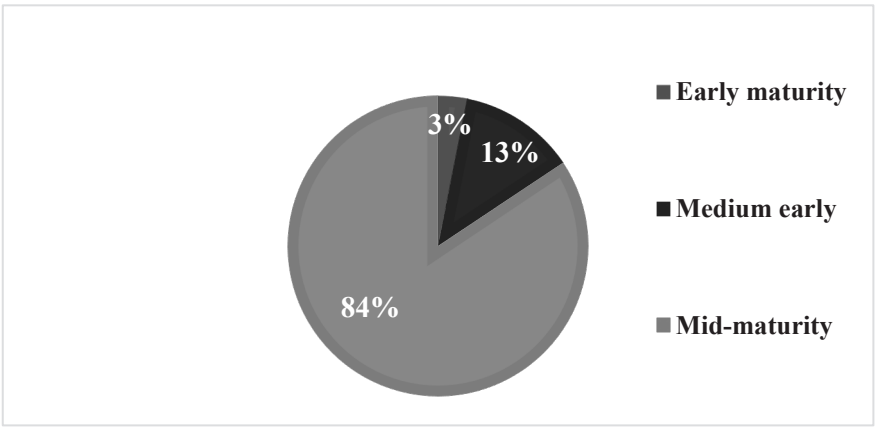

Fig. 1. Characteristics by the duration of samples vegetative period (Pushkin, 2016-2018).

Barley samples with a short vegetative period and high productivity were identified as sources of early maturity (Table 2).

Table 2. Early maturity sources (Pushkin, 2016-2018).

N kat VIR	Origin	Name	Seeding-maturity (days)			Average duration of vegetative period (days)	Yield, g/m²
			2016	2017	2018		
St 26209	Finland	Potra	63	75	66	68	332
31334	France	Niagara	66	84	69	73	452
31353	Germany	Power	67	83	74	75	216
31555	Germany	Brucefield	67	76	69	71	344

Lodging is one of the limiting factors in increasing yields in moisture and long daylight hours conditions. Lodging leads to a loss of 10–50% of the yield, interferes with mechanized harvesting, and disimproves the quality of grain and seeds [7].

Lodging resistance in cereals is closely related to the height and strength of the straw. Short-stemmed plants are generally more resistant to lodging. The varieties of Western European selection have a shortened, dense straw, resistant to lodging. Varieties height of plants over the years of study ranged from 45 to 90 cm. According to the results of a three-year study, lodging resistant standard variety "Suzdalets" was 80 cm and variety "Belogorskiy" was 95cm, although the height changed significantly over the years. Among the studied varieties, sources of lodging resistance with a shortened stem were identified (Table 3).

Table 3. Lodging resistance sources (Pushkin, 2016-2018).

N kat VIR	Origin	Name	Plant height, cm			
			2016	2017	2018	Average
St 22089	Leningrad district	Belogorskiy	103,75	107,5	75	95
St 27605	Belarus	Krinichniy	82,5	105	75	88
St 30314	Moscow district	Suzdalets	80	90	70	80
31331	France	Brennus	55	75	50	60
31332	Germany	Solist	60	70	50	60
31333	England	Odyssey	65	70	45	60
31343	Germany	Streit	70	65	45	60
31344	Germany	Steward	60	65	50	58
31345	Germany	Troon	70	65	55	63
31346	Germany	Juhata	70	70	55	65
31348	Germany	KWS Alciana	75	75	50	67
31349	Germany	Lisanne	65	70	50	62
31352	Germany	Publican	70	80	60	70
31353	Germany	Power	70	70	55	65
31556	France	Azalea	70	70	45	62

Grain productivity is the goal of all agricultural production. It is the important varieties property and is defined as the main factor among the breeding tasks. Grain productivity depends on many traits: productive tillering, grain mass per the main spike, spike length, spikelets number per spike, grains number per spike, weight of 1000 grain. Among the studied varieties, high-yielding samples exceeding the standard by more than 15% were not found. During 3 years study, productivity varieties at the standards level were identified (Table 4), it should be noted varieties "Niagara" (к-31334, *nutans*, France), "Tocada" (к-31341, *deficiens*, Germany), the yield of which exceeds the standards yield by 10 %.
The grain size expressed in the weight of 1000 grain is one of the most important yield structure traits. Weather conditions, violation of moisture supply, mineral nutrition of plants during the grain formation and maturity periods are significantly influenced on the grain size.

Table 4. Sources of high yield (Pushkin, 2016-2018).

N kat VIR	Origin	Name	Yield, g/m²			
			2016	2017	2018	Average
St 27605	Belarus	Krinichniy	325	517,5	207,5	350
St 30314	Moscow district	Suzdalets	190	645	270	368
31331	France	Brennus	260	690	160	370
31332	Germany	Solist	220	755	155	377
31333	England	Odyssey	240	735	100	358
31334	France	Niagara	300	870	185	452
31339	Germany	Ursa	260	710	218	396
31341	Germany	Tocada	250	815	290	452
31345	Germany	Troon	200	565	274	346
31346	Germany	Juhata	240	675	250	388
31347	Germany	KWS Bambina	220	685	257	387
31348	Germany	KWS Alciana	220	705	252	392

Varieties "Brennus" (к-31331*, nutans*, France), "Niagara" (к-31334, *nutans,* France), "Juhata" (к- 31346, *nutans*, Germany) were identified as coarse grain sources for the North-West region with weight of 1000 grain more than 45.0 g in dry years. Sources of coarse grain corresponding to the standards are shown in Table 5. We found that the Western European barley varieties yield depends on the weight of 1000 grain (r = 0.8±0.03). Other characteristics that determine the yield no correlation was found.

Table 5. High weight of 1000 grain sources (Pushkin, 2016-2018).

N kat VIR	Origin	Name	Weight of 1000 grain, g			
			2016	2017	2018	Average
St 27605	Belarus	Krinichniy	40,53	49,86	42,02	44,137
St 26209	Finland	Potra	44,72	51,26	44,04	46,673
St	Moscow district	Suzdalets	33,02	54,28	41,72	43,007

30314						
31331	France	Brennus	35,82	59,1	41,32	45,413
31334	France	Niagara	40,52	56,46	44,74	47,24
31340	Germany	Westminster	34,72	53,92	41,64	43,427
31341	Germany	Tocada	40,56	45,44	45,8	43,933
31346	Germany	Juhata	38,84	55,34	47,74	47,307
31348	Germany	KWS Alciana	32,8	54,94	46,76	44,833
31555	Germany	Brucefield	38,76	52,26	43,5	44,84

15 varieties had got an adaptation coefficient more than 1. Varieties "Niagara" (к-31334, France), "Tocada" (к-31341, Germany), "Juhata" (к-31346, Germany) have been identified with the highest adaptation coefficients.

4 Conclusions

As a result of studying a set of the Western European samples sources for breeding in the North-West region were identified. Cultivars "Brucefield" (к-31555, *parallelum*, Germany) early maturing, medium-height, large-grain, "Brennus" (к-31331, France) semi-dwarf, large-grain mid-season variety, "Niagara" (к-31334, *nutans*, France), "Tocada" (к-31341), "Juhata" (к-31346), "KWS Alciana" (к-31348) from Germany high-yielding, large-grain, semi-dwarf, high resistance to lodging and an adaptation coefficient more 1 can be used in the breeding process in the North-West region of the Russian Federation.

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Conflicts of Interest

Declare conflicts of interest or state "The authors declare no conflict of interest."

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