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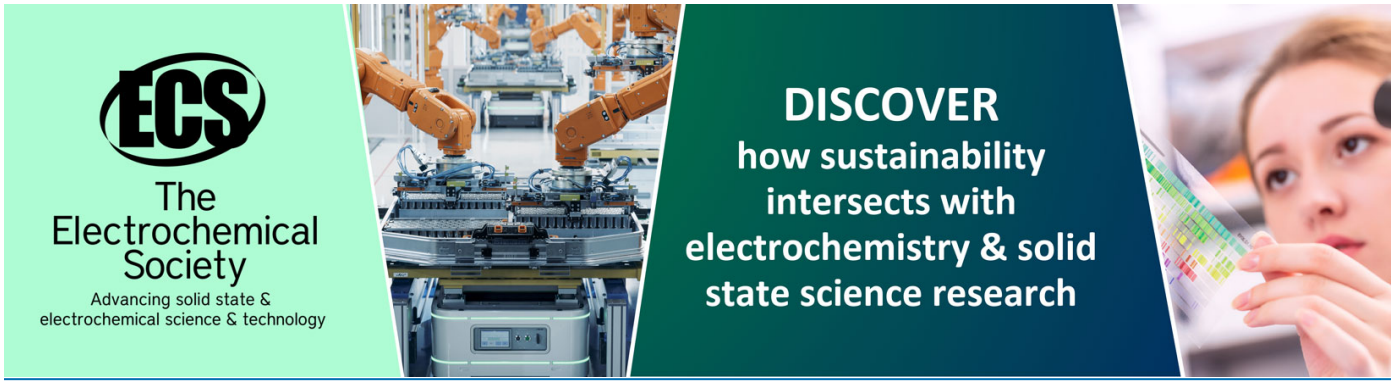

Evaluation of potato hybrids for the Arctic zone of Russia by the ranking method

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Abstract. In the Republic of Komi (Russia), potatoes are the most common vegetable crop, widely cultivated by both agricultural enterprises and the population in the private sector. Selection of varieties that meet such criteria as high yield, adaptability to soil and climatic conditions, high stability (the ability to produce an equivalent yield both under favorable and unfavorable environmental conditions), as well as resistance to the main phytopathogens that affect the tops and tubers (late blight , rhizoctoniosis, alternariosis, common scab, etc.) in the field is an important factor in ensuring Russia's food security in the Arctic zone. To select the most promising hybrids that passed through negative traits in the first phases of breeding, it is preferable to use ranking methods according to various parameters, such as ecological plasticity, stability, multiplicity coefficient, homeostaticity, etc. This will allow a more objective and complete assessment of the potential of potato genomes for creating new varieties adapted to the Arctic zone of Russia. The studies were carried out in breeding nurseries on the basis of the Institute of Agrobiotechnologies of the Federal Research Center of the Komi Scientific Center of the Ural Branch of the Russian Academy of Sciences (Russia, Syktyvkar) from 2018 to 2020. The following promising samples of potatoes were studied, the hybridization of which was carried out at the Federal Research Center for Potatoes named after A. G. Lorkh (Russia, urban settlement Korenevo): 1992-14 (Luck x Elmundo), 2000-60 (Colette x FZ 1867), 2118 -57 (2688-8 x Gala), 2139-5 (Courage x Aurora), 2142-1 (Dina x Kholmogorsky); the standards were zoned varieties of two groups of maturity: Udacha - early, early ripe, Nevsky - medium early. Based on the results of studies of promising potato hybrids for further selection in the conditions of the Komi Republic, the following hybrids were recommended by the sum of ranks and assessment of field resistance to phytopathogens: 1992-14, 2000-60 and 2139-5.

1. Introduction

Potato is the most common tilled crop cultivated in the Komi Republic (Russia) [1]. The Institute of Agrobiotechnologies of the Federal Research Center of the Komi Scientific Center of the Ural Branch of the Russian Academy of Sciences (Russia, Syktyvkar) continuously conducts the process of obtaining new high-yielding, adaptive to the soil and climatic conditions of the North of Russia and ecologically stable potato varieties with high field resistance to phytopathogens [2-3]. To select the most promising hybrids and their subsequent transfer to the state variety testing, a ranking method is used that allows you to compare existing hybrids with standards based on a sample of 14 parameters,

such as: average yield, yield range, stress resistance, genetic flexibility, plasticity, stability, multiplier coefficient , index of stability, coefficient of adaptability, homeostasis, breeding value, coefficient of variation and the level of stability of the hybrid relative to the applied standards varieties. Preference in further breeding to create promising varieties for the Arctic zone of Russia should be given to potato genotypes that scored less than standard varieties, and also showed high field resistance to phytopathogens. In 2020, five potato hybrids were studied that passed breeding selection for negative traits. Based on the results of these studies, the selected potato genotypes were transferred to competitive trial nurseries for further description and reproduction.

2. Materials and methods

The studies were carried out in breeding nurseries on the basis of the Institute of Agrobiotechnologies of the Federal Research Center of the Komi Scientific Center of the Ural Branch of the Russian Academy of Sciences (Russia, Syktyvkar). The following promising hybrids were studied, obtained from the A. G. Lorkh FRC of potatoes (Russia, Korenevo settlement): 1992-14 (Luck x Elmundo), 2000-60 (Colette x FZ 1867), 2118-57 (2688-8 x Gala), 2139-5 (Courage x Aurora), 2142-1 (Dina x Kholmogorsky). Varieties of two ripeness groups released and recommended for the Republic of Komi (Northern region of the Russian Federation) were used as standards: Udacha - early, early ripening, Nevsky - medium early [4].

Yield accounting was carried out for three years from 2018 to 2020. starting from the nursery of hybrids of the second year according to the technology of the potato breeding process [5]. Yield accounting was carried out by continuous harvesting of options for plots on the 90th day after the laying of the experiments. Phytopathological observations (registration of diseases) on tops were made every 8-10 days after the first signs of the disease appeared on the plants. The resistance of tubers to the main phytopathogens (late blight, early blight, rhizoctoniosis, common scab) was carried out simultaneously with harvesting.

Studies on ecological plasticity and adaptability were carried out by assessing the yield of potatoes in nurseries from 2018 to 2020 according to fourteen parameters and they were determined by the following methods: the level of stress resistance and genetic flexibility - A. A. Rosielle, J. Hamblin as presented by A. A. Goncharenko [6-7], plasticity and stability - S. A. Eberhart and W. A. Russell [8], multiplicity coefficient - V. A. Dragavtsev [9], stability index and coefficient of variation - A. A. Gryaznov [10], homeostaticity and selection value - V. V. Khangildin [11], yield range - V. A. Zykin [12-13], coefficient of adaptability - L. A. Zhivotkov [14], indicator of the level of variety stability in comparison with Nevsky and Udachi - E. D. Nettevich [15-16].

Statistical data processing was carried out by analysis of variance [17] and data analysis package Microsoft Office Excel 2010 on a personal computer.

3. Results and Discussion

The weather conditions of the beginning of the growing season (June) over the years of observation were distinguished by low temperatures (-1.3, -1.2 and -1.3 °C from the norm, respectively). In addition, nightly return frosts were noted in 2018. Precipitation patterns varied greatly from year to year. So in 2018, precipitation fell at the level of the climatic norm, in 2019 it was 25% above the norm, and in 2020 it was only 50% of the average climatic value. The temperature regimes in the phases of budding and flowering of plants were very diverse over the years of research. So, 2018 and 2020 were distinguished by elevated temperatures (by 2.0 and 2.5 °C above the norm), while in 2018 precipitation was 25% above the norm, in 2020 it fell only 70% of the average long-term values. July 2019 was cold (2.1°C less than the norm) and rainy (181% of the norm).

During the period of intensive development of tubers (August), the most favorable conditions were in 2018 and 2020, when the temperature was within the climatic norm, and precipitation fell slightly below long-term indicators. In August 2019, in turn, the July trend (cold and rainy weather) continued, which negatively affected the formation of the potato crop and led to a significant spread of diseases.

I. Ranking of potato hybrids and varieties was carried out by calculating fourteen parameters for tuber yield. The results of yield assessment by years of research are shown in table 1.

Table 1. Productivity of potato varieties and hybrids in 2018-2020.

Hybrid/variety	Productivity, t/ha			
	2018	2019	2020	Average (X_{av})
1992-14	35.0±1.6	28.5±1.4	30.0±1.8	31.2
2000-60	23.6±3.5	25.0±3.7	22.3±3.2	23.6
2118-57	17.6±0.6	27.0±0.2	22.4±0.9	22.3
2139-5	28.7±2.3	24.5±2.9	31.7±1.6	28.3
2142-1	22.1±2.6	26.0±1.7	28.6±3.5	25.6
Nevsky, st	28.1±2.5	20.0±2.3	26.4±2.6	24.8
Udacha, st	17.9±3.0	15.3±1.4	21.4±4.6	18.2
NSR_{05}	3.2	7.4	8.8	

The yield of potato hybrids and varieties varies greatly over the years of research, which was significantly affected by unstable weather conditions, characterized by sharp changes in temperature and precipitation in the phases of plant development, which is very typical for the Arctic zone of the North of Russia and the Komi Republic in particular. So in 2018 and 2019, only one hybrid reliably proved to be better than the Nevsky variety standard - 1992-14. The rest of the hybrids, with the exception of 2118-57 in 2018, significantly exceeded the standard Udacha variety. In 2020, all varieties and hybrids showed a comparable yield, but only hybrids 1992-14 and 2139-5 significantly exceeded the standard Udacha variety, which is associated with a lack of moisture during the formation of the crop.

Thus, the analysis of the yield obtained over three years of research does not give a sufficient idea of the superiority of the genotypes of some hybrids over others or standards. For their objective and reliable assessment, based on the results of table 1, a ranking of hybrids was carried out, presented in table 2. Preference for further selection was given to potato genotypes that scored the lowest number of points, that is, ranked first or third in most of the parameters considered.

Table 2. Ranking of potato hybrids and varieties according to the parameters of ecological plasticity and adaptability.

Ranking *	Hybrid/variety						
	1992-14	2000-60	2118-57	2139-5	2142-1	Nevsky, st	Udacha, st
X_{av}	1	5	6	2	3	4	7
SR	3	1	6	4	3	5	2
G_f	1	5	6	2	3	4	7
b_i	5	6	7	1	4	3	2
σ_d^2	6	2	7	3	4	5	1
KC	5	6	7	2	4	3	1
SI	2	1	7	3	4	5	6
KA	1	5	6	3	3	4	7
Hom	6	7	1	5	4	3	2
S_c	1	3	6	2	4	5	7
d	2	1	6	3	3	5	4
CV	2	1	6	3	3	5	4
$PUSS_{Nevsky, \%}$	2	1	6	3	4	5	7
$PUSS_{Udacha, \%}$	2	1	6	3	4	5	7
Σ_{ranks}	37	44	77	35	46	56	57

* X_{av} - average yield; SR - stress resistance; G_f - genetic flexibility; b_i is plasticity; σ_d^2 – stability; KC - multiplier coefficient; SI - stability index; KA - coefficient of adaptability; Hom - homeostatic index; S_c - breeding value; d - is the yield range; CV - the coefficient of variation; PUSS - indicator of the level of stability of the variety.

The ranking of hybrids and varieties of potatoes made it possible to unequivocally establish the fact that the hybrid 2118-57 did not meet the requirements. Its rank level was 77 points, which is almost twice as high as other hybrids and 20 points higher than the standards. This hybrid received the first rank only in terms of homeostaticity.

Two hybrids have the best performance in terms of the sum of ranks: 1992-14 (the sum of ranks is 37 points) and 2139-5 (the sum of ranks is 35 points). They have high yields, genetic flexibility, stability index, breeding value, yield range and variety stability relative to standards. However, the 1992-14 hybrid has low ranks in terms of such indicators as stability, multiplicativeness and homeostasis, and it can be assumed that its yield depends more on weather factors than other hybrids and varieties.

Hybrids 2000-60 and 2142-1 showed an intermediate result, gaining the sum of ranks of 44 and 46 points, respectively, which is 10 points higher than that of the standard varieties.

II. Phytopathological assessment of the field resistance of potato hybrids and varieties to late blight, Alternaria, rhizoctoniosis and common scab on average over three years is presented in table 3.

Table 3. Field resistance of potato varieties and hybrids to phytopathogens on average for 2018-2020.

Hybrid/variety	Tuber resistance, score			Leaf resistance, score		
	Common scab	Rhizoctoniosis	Late blight	Late blight	Rhizoctoniosis	Alternariosis
1992-14	7-9	9	9	8-9	9	8-9
2000-60	7-9	9	7-9	8-9	9	9
2118-57	3-9	9	3-9	8-9	9	9
2139-5	7-9	9	9	9	9	9
2142-1	3-7	9	3-9	8-9	9	9
Nevsky , st	4-5	9	9	7-8	9	6-9
Udacha , st	4-8	9	1-9	4-8	9	4-9

Evaluation of field resistance to the main phytopathogens revealed high resistance of all hybrids to rhizoctoniosis on plant tops and tubers, Alternaria and late blight of tops. The resistance of tubers to common scab of the studied hybrids is moderate. In hybrids 2118-57 and 2142-1, low resistance of tubers to late blight and common scab was noted, which is a negative factor for the further breeding process.

4. Conclusion

Based on the results of studies of promising potato hybrids, hybrids 1992-14, 2000-60 and 2139-5 are recommended for further selection in the conditions of the Komi Republic in terms of the sum of ranks and field resistance to phytopathogens. These accessions were transferred to competitive testing nurseries for further study and description according to a set of economic characteristics for distinctness, uniformity and stability.

Based on the results of a comprehensive assessment of five promising potato hybrids by the method of ranking according to fourteen parameters and phytopathological control, three accessions were selected, which were submitted for further selection to competitive trial nurseries and description for a set of economic characteristics for distinctness, uniformity and stability. The samples were ranked according to the following parameters: average yield, yield range, stress resistance, genetic flexibility, plasticity, stability, multiplier coefficient, stability index, adaptability coefficient, homeostaticity, breeding value, coefficient of variation and the level of stability of the hybrid relative to the applied varieties of standards of two ripeness groups - Luck (early, early ripening) and Nevsky (mid-early). In the course of the research, the hybrid 2118-57 was rejected, as it scored the highest sum of ranks - 77 points with low field resistance to common scab and tuber late blight. Sample 2142-1 scored the sum of ranks - 46 points, however, showed the field resistance of tubers to scab and late blight, and therefore was excluded from the further selection process. Hybrids 1992-14, 2000-60 and

2139-5 exceeded the control by the sum of ranks (37, 44 and 36 points, respectively), and also had high field resistance to late blight of leaves (8-9 points), late blight on tubers (7-9 points), rhizoctoniosis of tops and tubers (9 points), Alternariosis (8-9 points), common scab (6-9 points) and were selected for further breeding process and development of new varieties of potatoes for the Arctic zone of Russia.

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