Assessment of breeding hybrid potatoes in irrigated conditions of the steppe zone of the Southern Urals

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Abstract. The creation of varieties with a high potential productivity and adaptability applied to the environmental conditions of a particular climatic zone is the main goal for breeding programs. The purpose of this work is studying and identifying the most adaptable hybrid materials that are most adaptable to the conditions of the steppe zone of the Southern Urals for selection, combining high productivity, resistance to major diseases with the complex of economically valuable traits. The objects of research were breeding hybrids 10.76.32; 02.40.17; 01.2.50; 01.12.51; M07.48.19; 05.57.32 and 10.02.19 obtained in the potato breeding laboratory of the South Ural Scientific Research Institute of Horticulture and Potato. Assessment of the represented volume of samples was carried out according to the morphological characteristics of plants, productivity, marketability, starch content in potato tubers, culinary type, taste, resistance to pathogens (Erwinia carotovora atroseptica, Clavibacter michiganensis sepedonicus, Dickey pectobacterium atrosepticum, Phytophthora infestans, Streptomyces scabies, PVM, PVS, PVX, and PVY). The breeding hybrids under study significantly exceeded the variety - standard Nevsky - in terms of yield by 97-1182g per bush. The highest starch content was recorded in breeding hybrids: 02.40.17 (18.4%), M07.48.19 (18.2%), 01.2.50 (17.6%). In taste the highest tasting score received - M07.48.19, 02.40.17 (5 points), 05.57.32 (4.5 points), 10.02.19 (4.7 points). The culinary type assessment showed that to the salad type (preferably not fall apart) applies the selection hybrid 10.76.32. Over the years of research low susceptibility to the pathogens under consideration was possessed by the following hybrids: 01.12.51, M07.48.19 and 05.57.32.

1. Introduction
Growing demands for the newly created potato varieties, primarily in their resistance to widespread and adaptable disease populations, as well as their ability to resist the effects of abiotic and biotic stressors, contribute to the continuous expansion of the potato assortment [1].

Varieties of foreign selection prevailed in the Southern Urals are not sufficiently adapted to local conditions [2]. Due to the high cost of agricultural machinery, protective equipment and mineral fertilizers, the manufacturer cannot influence the potato yield, which over the past five years has not exceeded 20 t/ha on average and is subject to significant falls over the years [1, 3].

Formulation of the problem. The cheapest and most effective way to increase potato productivity and its stability is a variety and its importance is constantly increasing. Therefore, cultivation of potato
varieties that are able to maximize the potential of the genotype under constantly changing growing conditions is an urgent problem.

The main task of breeding work is the selection of promising samples combining the maximum possible number of positive economic and biological characteristics.

**Research objective.** The objective point is obtaining experimental data on the study and selection of the most adaptive to local conditions perspective hybrid breeding material that combines high productivity, resistance to major diseases with a complex of economically valuable traits for creating new varieties of potatoes.

2. **Materials and methods**

The research was carried out on the irrigated plot of LLC "Agrofirm Krasnokholmskaya" of the Ilek district in 2016-2019. The soil of the experimental plot - southern residual meadow, weakly humus medium-heavy, heavy and medium loamy with a humus content (GOST 26213-91) in arable layer of 3.2% is characterized by low supply of mobile forms of nitrogen - 6.35 mg/100 g of soil (GOST 26107-84) and phosphorus - 8.63 ... 9.96 mg/100 g of soil and medium - with mobile potassium - 22 mg/100 g of soil (GOST 26205-9).

The predecessor is a boneless rump. After harvesting, potash fertilizers were added annually, in spring - ammonophos and ammonium nitrate, the general norm was N$_{75}$ P$_{120}$ K$_{112}$.

**Object of study.** The initial material for the research were breeding potato hybrids obtained in the potato breeding laboratory of the FSBSI of the "South Ural Research Institute of Horticulture and Potato": 10.76.32 (Krepysh and Bora Valley); 02.40.17 (Spiridon and Red Star); 01.2.50 (Zarevo and Nevsky); 01.12.51 (Cosmos and Lugovskoy); M07.48.19 (Pamyati Osipovoy and 807-11); 05.57.32 (Spiridon and Shurminsky) and 10.02.19 (Lazarus and Concord). A zoned potato variety Nevsky was taken as a standard. These hybrids (first generation) were obtained by crossing polyploid forms of various wild species (S. andigenum, S. stoloniferum, S. vernei, S. Chacoens) with potato varieties carefully selected in accordance with the selection goals.

**Experiment design.** Potato planting was carried out in half-ridges with a GRIMME potato planter with simultaneous etching of tubers. The depth of incorporation is 3-5 cm from the top of the ridge to the top point of the tuber. Cresting was carried out by the GRIMME combining machine. During the growing season, crops were treated 3 times with herbicides and 2 times with fungicides.

Irrigation was carried out with the DM-100 "Frigate" sprinkler machine from 6 to 9 times depending on weather conditions with an irrigation rate of 2750-3350 m$^3$/ha, the irrigation rate during the test period varied from 250 to 450 m$^3$/ha.

**Climatic conditions.** During the research period the most favorable meteorological conditions developed in 2016 and 2019, the vegetation periods were characterized by a sufficient amount of precipitation and heat (192 and 143mm respectively with the sum of the effective temperatures 2220 and 2260$^{\circ}$C). During the growing season in these years 19 and 34 days were noted with a minimum relative humidity of 30% or less at 0.64 and 0.57, respectively. Due to irrigation, abundant rainfall, the absence of atmospheric drought during the interphase period of potato development, budding - flowering, in the second half of July-early August, tuberization took place in favorable conditions. The vegetation periods of 2017 and 2018 were less favorable for the growth and development of potatoes due to the lack of precipitation (54.4 and 79 mm) with the sum of effective temperatures of 2560 and 2310$^{\circ}$C respectively, the number of days with atmospheric drought from May to August was 16 and 29 days, the hydrothermal coefficient (HTC) for growing season – 0.31 and 0.29.

The agricultural technology of potato cultivation was consistent with that generally accepted for the research area.

The counts of diseases and viruses (Y, X, M, S) were carried out by visual inspection of each plant in the sample according to GOST T 29267-91, GOST R 55329-2012 and diagnosed by immunoenzyme analysis - test. The degree of damage by late blight, ring rot, common scab, blackleg and viruses was
determined according to a 9-point scale as described in the "Methodology of the Guidelines for maintaining and studying the world potato collection" All-Russian Institute of Plant Genetic Resources [4]. Score 1 - more than 50% of infected plants, 3 - 50%, 5 – up to 25%, 7 - 10%, 9 - infected plants were not observed.

When conducting research, we were guided by the "Methodology of Research on Potato Culture" [5], the "International Classifier of CMEA" [6], "Methodological Recommendations on the Methodology of the Breeding Process for Potato Culture" [7].

**Statistical processing.** Statistical analysis was performed using the "Microsoft Office" software package using the “Excel” program (“Microsoft Office”, USA).

## 3. Results and discussion

Today, many modern potato varieties (like other crops) are often genetically similar and have a rather narrow genetic base [8, 9].

Direct selection of high-yielding forms only for the final crop cannot be effective and should not be only one-sided therefore, and should at least rely on the biological nature of the body.

Morphological features of the aerial parts of plants and tubers play an important role for the hybrid, i.e. definite correlation between different features make it possible to select the most valuable forms.

As a result of the studies, two hybrids with upright plants of medium height, three hybrids with a spreading plant with high, medium and low heights and two hybrids with semi-upright plants of medium height were identified. The bulk of the plants have a stem type of foliage (Table 1).

| Selection hybrids | Morphological features |
|-------------------|------------------------|
| 10.76.32          | Upright, medium height, stem type of foliage. elongated- oval, depth of eyes - very shallow, peel color - blue, color of pulp - blue - mottled. |
| 02.40.17          | Spreading, tall, intermediate type of foliage. oval – rounded, depth of eyes - shallow, color of peel - yellow, color of pulp - yellow. |
| 01.2.50           | Upright, medium height, stem type of foliage. oval – rounded, depth of eyes -medium , peel coloring - light - beige, the color of pulp - yellow. |
| 12/01/51          | Spreading, medium height, stem type of foliage. rounded, depth of eyes - small, peel coloring - light - beige, pulp - yellow. |
| M07.48.19         | Spreading, low, stem type of foliage. oval – rounded, depth of eyes - small, peel coloring - light - beige, the color of pulp - white. |
| 05.57.32          | Semi-upright, medium height, stem type of foliage. elongated, the depth of the eyes is shallow, the color of peel is partially red, color of pulp light- yellow. |
| 02/10/19          | Semi-upright, medium height, intermediate type of foliage. elongated, the depth of the eyes is very shallow, the color of the peel is partially red, the color of the pulp - light yellow. |

The depth of the eye of the studied hybrids varied from very shallow to medium depth. In general, the main part of hybrids differed by a more superficial occurrence of ocelli, with the exception of 01.2.50.

Thus, of the above, the greatest interest in the conditions of the steppe zone of the Southern Urals is presented by breeding hybrids with the following characteristics: a plant is semi - and erect, high, or medium height, foliage type is intermediate or stem, tubers - round or elongated with a very shallow or
shallow depths of the eyes, with red and white skin peels, with white or yellow pulp: 01.2.50, 10.02.19.

The most important sign for assessing the biological resource is productivity (total weight of tuber (g) from one bush), since it quantitatively characterizes the yield of the product resulting from the cultivation of potatoes.

The maximum productivity from the bush on average for four years was obtained in the variants with planting of breeding hybrids: 01.12.51, 05.57.32, M07.48.19 and 02.40.17, respectively 1700 g, 1620 g, 1500 g and 1401 g from a bush, for other options varied from 615 g from the bush (10.76.32) to 1300 g from the bush (10.02.19). All other options exceeded the variety standard Nevsky in productivity (518 g per bush) (Table 2).

The most valuable are potato hybrids, obtaining such a feature as multituberosity, which is one of the components of productivity. The number of tubers from one bush ranged from 9 pieces in the selection hybrid 10.76.32 to 32 pieces in 01.12.51.

Considering the structure of the potato crop, we see that some of the tested hybrids exceed the indicators in terms of marketability and mass of marketable tubers in comparison with the standard variety Nevsky. The data indicate that the studied hybrids had marketability within 85-98%, which makes them economically valuable. It should be noted that hybrids differed in the highest yield marketable products and higher yield of marketable products: 01.12.51 - 98% 02.40.17 - 95.6%, 10.76.32 - 94.2%, M07.48.19 - 90.8%. The marketability for all options varied within 85-98%.

Hybrids were distinguished by the highest average weight of a commodity tuber: 10.76.32 (201.8g); 10.02.19 (161.0g). The smallest average weight of tubers was observed in two variants: 01.12.51- 95.8g and 02.40.17 – 96.7g.

The quality of potato tubers and their taste are judged by the amount of starch and dry matter in it, which are determined primarily by its varietal characteristics, which are formed initially in hybrid populations of various combinations [10]. As is known, the starchiness of potato varies depending on weather conditions, place of growth and variety. In the conditions of the steppe zone of the Southern Urals, selection potato hybrids with very low (less than 10 %) and very high (22 %) starch content was not detected. Of the 7 breeding hybrids analyzed, the starch content in potato tubers varied from 18.4% (02.40.17) to 12.9% (10.02.19), in the standard version (Nevsky variety), the starch content in the tubers was limited to 14.1%.

In terms of taste, almost all the studied breeding hybrids had high indicators, with the exception of 10.76.32 (3 points). The greatest tasting score was received by the options - M07.48.19, 02.40.17 (5 points), 05.57.32 (4.5 points), 10.02.19 (4.7 points).

| Selection hybrids, variety | Productivity, g/bush | Quantity of tubers, pieces/bush | Marketability, % | Average weight of marketable tuber, g | Starch content, % | Taste, points | Culinary type |
|----------------------------|----------------------|--------------------------------|-----------------|--------------------------------------|------------------|--------------|--------------|
| Nevsky                     | 518 ± 22.6           | 11 ± 1.1                       | 87.0            | 76.3 ± 4.5                           | 14.1             | 3.7          | AB           |
| 10.76.32                   | 615 ± 18.1           | 9 ± 1.0                        | 94.2            | 201.8 ± 5.4                          | 13.7             | 3.7          | B            |
| 02.40.17                   | 1401 ± 109.9         | 16 ± 2.5                       | 95.6            | 96.7 ± 3.1                           | 18.4             | 5.0          | C            |
| 01.2.50                    | 1173 ± 88.1          | 15 ± 1.1                       | 94.6            | 123.7 ± 9.0                          | 17.6             | 4.3          | BC           |
| 01.12.51                   | 1700 ± 140.4         | 32 ± 2.1                       | 98.0            | 95.8 ± 4.1                           | 15.5             | 4.7          | C            |
| M07.48.19                  | 1500 ± 110.0         | 14 ± 1.0                       | 90.8            | 105.2 ± 2.7                          | 18.2             | 5.0          | CD           |
| 05.57.32                   | 1620 ± 103.0         | 21 ± 1.5                       | 94.3            | 122.3 ± 7.4                          | 16.0             | 4.5          | C            |
| 10.02.19                   | 1300 ± 96.6          | 16 ± 2.1                       | 85.4            | 161.0 ± 10.5                         | 12.9             | 4.7          | C            |
| NDS _05                    | 3.6                  | 1.2                            | -               | 1.4                                  | 2.9              | -            |              |

In modern world practice table potato varieties are usually divided into four culinary types, (culinary type A) to more friable types (B, C, D) intended for use in cooking specific dishes.
Evaluation of the culinary type of the studied breeding hybrids showed that Nevsky belongs to the intermediate culinary type AB, and to the culinary type B, C and D, which is due to a violation of the integrity of the peel, a decrease in density, an increase in mealiness and granularity of the pulp relates the rest of the studied variants.

In recent years the protection of plants in many countries has attracted the attention of experts to the harmfulness of various pathogens on potatoes [11].

All studied potato breeding hybrids, as well as the standard variant (Nevsky variety) were not affected during the observation period by pathogens (Erwinia carotovora atroseptica, Clavibacter michiganensis sepedonicus, Dickey pectobacterium atrosepticum).

According to scientists [12, 13] late blight remains one of the most serious agronomic and economic problems in potato growing. In the steppe of the Southern Urals in the field, the infection of potato plants by this pathogen occurred due to the influence of various factors, it spread especially rapidly in the rainy years (in 2016 and 2019), as well as during a sharp change in day and night temperatures in August. Therefore, the search and creation of source material with resistance to late blight always remains very relevant [14].

The primary symptoms of late blight were observed on the leaves at the beginning of the third decade of July. The average degree of plant damage by late blight (Phytophthora infestans) (7 points) was observed in samples 01.12.51, M07.48.19, and on the standard variety Nevsky and breeding hybrid 10.76.32, plant damage in early August was observed up to 45% (3 points) (Table 3). On the other hybrids, no damage was noted.

| Pathogens                              | Variety, hybrids | Nevsky 2016-2019 | 10.76.32 2019 | 02.40.17 2019 | 01.12.50 2017 | 01.12.51 2017 | 05.57.32 2019 | 10.02.19 2019 |
|----------------------------------------|------------------|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Phytophthora infestans                 |                  | 3                 | 3            | 9            | 9            | 7            | 7            | 7            |
| Streptomyces scabies                  |                  | 5                 | 5            | 7            | 7            | 7            | 5            | 9            |
| Erwinia carotovora atroseptica        |                  | 7                 | 7            | 9            | 9            | 9            | 9            | 9            |
| Clavibacter michiganensis sepedonicus |                  | 9                 | 9            | 9            | 9            | 9            | 9            | 9            |
| Dickey pectobacterium atrosepticum    |                  | 9                 | 9            | 9            | 9            | 9            | 9            | 9            |
| PVX                                    |                  | 1                 | 9            | 9            | 9            | 9            | 9            | 9            |
| PVS                                    |                  | 1                 | 1            | 1            | 9            | 9            | 9            | 9            |
| PVM                                    |                  | 1                 | 1            | 9            | 9            | 9            | 9            | 9            |
| PVY                                    |                  | 1                 | 9            | 9            | 9            | 9            | 9            | 9            |

Over the years of research, Streptomyces scabies has been intensely manifested in 2016. The standard variety Nevsky (tuber damage from 12.8% to 13.6%), as well as breeding hybrids 10.76.32 and 10.02.19, which was 5 points, turned out to be the most vulnerable to common scab in the studied years. It should be noted that the 05.57.32 hybrid was not affected by Streptomyces scabies.

The PVY virus is considered the most dangerous, which is detected annually in different countries, crop losses from it range from 20% to 90%. In his work Karasev, Gray [15] indicates that losses depend on the variety, the number of infected plants in the field, the time of infection, and a number of other factors.

As a result of studies in 7 studied hybrids, the pathogens PVX and PVY were not observed, with exception of the standard version of Nevsky.

The PVM pathogen was found in the studied breeding hybrids 05.57.32, 02.40.17, 10.02.19, samples with a high susceptibility to the PVS pathogen had:10.76.32,06.15.20,01.02.50, all the studied had a low susceptibility to the PVX pathogen and PVY options, except for the standard variety Nevsky.

Thus, hybrids 01.12.51, M07.48.19 and 05.57.32 practically had no damage to plants and potato tubers by the above listed pathogens during the four years of study.
4. Conclusions
Thus, the following distinguished breeding potato hybrids M07.48.19, 01.12.51 and 05.57.32, combining high productivity, low susceptibility to major diseases with a complex of economically variable traits are of particular interest for further breeding work in the steppe zone of the Southern Urals.

The results presented in this article can be considered as the initial stage of the search for genotypes promising for selection and the characteristics of their adaptive properties associated with yield formation and obtaining information necessary for the development of modern selection methods.

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