

RESEARCH ARTICLE

The influence of environmental factors of the northern and high-mountain territories on the formation of the yield of tubers of early-maturing potato varieties

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ABSTRACT

The aim of the research was to study the yield indicators of 36 early-ripening potato varieties in the northern region (Arkhangelsk) and the highlands of the North Caucasus (altitude 2500m above sea level). Experimental work was carried out in 2015-2020. Features of the northern zone - a light period of up to 21 hours in June - July, contributing to an increase in the duration of interphase periods of plant development. In the highlands, a short daylight hours of 14 hours, a sharp drop in daytime temperatures 15,1 - 25,8°C and night temperatures 7,8 - 15,2°C and intense solar insolation. Peat-podzolic-gley soils of the northern region are characterized by low humus (3,7%) and high - potassium (240 ... 267 mg/kg) in comparison with mountain meadow subalpine soils of high mountains (6,7% and 102 ... 120 mg/kg). Potatoes were planted in the first decade of June, harvesting - in early September. Was planted 25 tubers of each variety according to the scheme 0,7 × 0,3 m, the area of the accounting plot was 5.25 m². Using cluster, discriminant analyzes, the varieties were grouped according to a set of indicators: the multiplication factor, the yield of one plant and the average mass of tubers. In the northern region, the best were the varieties that formed from 8,1 to 11,4 tubers with an average weight of 37,0 ... 67,9 g and a yield of 400 ... 633 g. In the highlands, the varieties that formed 11,8 ... 19,8 pcs., 56,5 ... 70,6 g and 830 ... 1140, respectively, were the most productive. According to the results of the assessment of plasticity of 36 early-ripening potato varieties, they were resistant to extreme environmental conditions in northern and high mountains. zones were characterized by only five varieties: Daryonka, Red Lady, Breeze, Leader, Gulliver.

KEYWORDS:

potatoes, variety, early maturity, field collection, Bank of healthy potato varieties, plasticity, northern zone, highlands.

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INTRODUCTION

The biological feature of potatoes is a vegetative way of reproduction. This is associated with problems caused by the physiological aging of the crop and the accumulation of specific pathogens that cause crop losses. In this connection, biotechnological methods are most widely used in potato seed production. [7,14]. The use of meristem-tissue operations makes it possible to preserve the typicality of the biomaterial while maintaining the potato collection in vitro

[8,12]. However, with long-term cultivation of potatoes in

vitro, there is a threat of fixing modifications for certain economically valuable traits and properties [4,5]. The best conditions for the conservation of potato genetic diversity are in situ conditions that minimize the loss of varietal resources [1,2,9]. Such deviations affect the varietal purity of the seed produced material [5,6,] In the field collection, there are still risks of infection of plants with viral diseases, and the conservation of varieties becomes problematic.

Attaching great importance to solving the problem of preserving varietal identity and based on modern world experience, in the early 2000s, Bank of Healthy potato varieties was created in Russia. The first expeditions organized by Bank of Healthy potato varieties were organized on Bolshoy Solovetsky Island in 2004-2006 [11]. Later the collection was placed and it is maintained in cleanest phytosanitary conditions at the coast of White Sea (Arkhangelsk region) and is duplicated in the high-mountainous zone of the North Caucasus at an altitude of 2300 ... 2500 m above sea level [10].

The purpose of the work is to study the interaction between the main indicators that form the yield of early potato varieties in the northern region and the highland zone.

MATERIALS AND METHODS

The experimental work was carried out in 2015-2020 in the conditions of the Russian European North (Arkhangelsk region - 64° 32.3636'0"N and 40° 31.0163'0"E) and in the highlands of the North Caucasus at an altitude of 2300 - 2500 m above sea level. (Republic of North Ossetia - 42° 52'12"N and 43° 57'33"E).

Soils in the Arkhangelsk region are peat-podzolic-gley with a predominantly flat relief. Agrochemical indicators of the site where the BZSK was located: humus content - 3,66% (low), nitrogen - 43...45 mg/kg soil (average), mobile forms of phosphorus and potassium high - respectively 240...267 and 160...170 mg/kg soil. The optimum air and soil temperature for planting potatoes occurs in the first decade of June. The most favorable conditions for the culture were the conditions of the field seasons 2016-2018. During these years, the excess of average daily temperatures in July - August by 1,3 ... 3,0°C, combined with an abundance of precipitation, contributed to the intensive growth of plants and tuberization of potatoes. During the growing seasons of 2015 and 2019, insufficient heat supply to plants in July (the average daily air temperature is below the multi-year norm by 3,3 ... 3,6°C) and August (by 1,0 ... 1,6°C) adversely affected the growth processes and the formation of tubers yield. In 2020, a moisture deficit during the critical period of plant development - during the flowering of potatoes, affected the indicators of its productivity.

In the North Caucasus, at an altitude of 2500 m above sea level, the air is clean and transparent, the voltage of solar radiation is high, with a high content of ultraviolet rays. In the alpine zone, the length of the day sharply differs from the northern one and during the growing season of potatoes is characterized by a smooth transition from 15 h in June to 14 h in early August.

Highland soils belong to a variety of mountain meadow subalpine. Agrochemical analysis of soil samples of the experimental site: the humus content in the upper horizon is 6,7% (high), the reaction of the soil solution is pH 5,8 (weakly acidic), the nitrogen content is 43 ... 45 mg/kg of soil (average), available forms of phosphorus are 102 ... 120

(high) and potassium - 161 ... 180 mg/kg soil (high). During the years of research, daytime temperatures during the growing season of potatoes in the highlands varied within 15,1 ... 25,8°C, with a sharp decrease at night to 7,8 ... 15,2°C. Precipitation in the mountains fell systematically and in most cases in the form of torrential rains. The amount of precipitation during the growing season was 410 ... 613 mm.

For a comparative analysis of the efficiency of growing potatoes in northern and high mountain conditions, 36 early ripening potato varieties were used. Planting was carried out in the first ten days of June, 25 tubers of each variety were planted according to the scheme 0,7 × 0,3 m; accounting plot area - 5,25 m². Harvesting of the field collection was carried out at the beginning of September, while the multiplication coefficient, potato productivity and the average weight of one tuber were determined.

The ecological plasticity of the cultivars was assessed using the regression coefficient (bi) for the number of tubers and the productivity of one plant [3]. At the same time, bi reflects the average response of the genotype to fluctuations in environmental conditions, which manifests itself in phenotypic variability. Zero or close to zero bi value indicates a neutral response of the genotype to the variability of environmental conditions. Such varieties are characterized by high plasticity to abiotic factors of the region. Indicator bi >1,0 samples of intensive type, which respond well to the improvement of growing conditions, and with bi <1,0 with low ecological plasticity, weakly responding to changes in environmental factors.

Stability variation Si² shows how reliably the genotype corresponds to the plasticity estimated using the regression coefficient. The closer Si² is to zero, the less the empirical values differ from the theoretical ones, and the sample shows a more stable yield in different environmental conditions.

Statistical processing of experimental data was carried out using separate methods of multivariate statistical analysis - factorial, cluster (Ward's method, Euclid distance) and stepwise discriminant analyzes using the Microsoft Excel 2010 software package and the StatGraphics Centurion XV computer program.

RESULTS AND ITS DISCUSSION

Environmental conditions have a significant impact on the passage of interphase periods of potato development. In the northern zone, the beginning of sprouting was recorded in the second decade of June, mass - at the end of the third decade. The flowering phase depended on varietal characteristics, its onset was observed from the third decade of July to the end of the first decade of August. On the 45- ... 55th day from planting, early varieties marked the beginning of tuberization, while the plants formed 2 - 3 stems and a habit at the level of 50 ... 60 cm. By the harvesting period, the length of the stems reached 60 ... 65 cm.

In mountainous conditions, potato shoots appeared 6 ... 10

days later relative to the northern zone. Full shoots of most varieties were noted on the 20 ... 28th day after planting. On the 47 ... 58th day, the plants entered the budding phase. Mass flowering was noted in the first ten days of August (60 ... 70 days after planting). The plants were distinguished by a developed above-ground vegetative mass; by the harvesting period, the length of the stems, depending on the variety, varied from 70 to 80 cm. The number of stems varied from 4

to 6 per plant.

The studied indicators - yield, number of tubers per plant and their average weight, considered as variables, were used to determine the features of the structure of relationships between them. Using factor analysis for each zone, two factors F1 and F2 were obtained (table).

Table - Results of factor analysis

Variable	Factor loads			
	F1 (65,0%)	F2 (34,6%)	F1 (62,8%)	F2 (37,0%)
	northern zone		high-mountain zone	
Number of tubers per plant, pcs.	0,995	-0,081	0,983	-0,176
Tuber yield, g	0,821	0,565	0,917	0,396
Average weight of one tuber, g	0,038	0,998	0,039	0,999

According to signs and high factor loads F1, a direct relationship was established between the multiplication factor and the productivity of potatoes. The high value of the factor load F2 with the variable "average weight of one tuber" indicates the independent nature of its manifestation in the studied varieties.

set of indicators (using cluster analysis), three groups of varieties were identified in each zone. In the northern zone, the correctness of grouping is 97,22% supported by discriminant analysis. The main discriminators, reliably dividing the varieties into groups, were the indicators of the yield of one plant and the average mass of the tuber. The first group, including 10 varieties, differed in the largest studied indicators (Fig. 1)

When distributing an identical set of potato varieties over a

Indicator			
Centroids			
TN	9,2	6,9	7,4
TY	459,9	323,6	286,4
W1	50,1	47,6	38,7

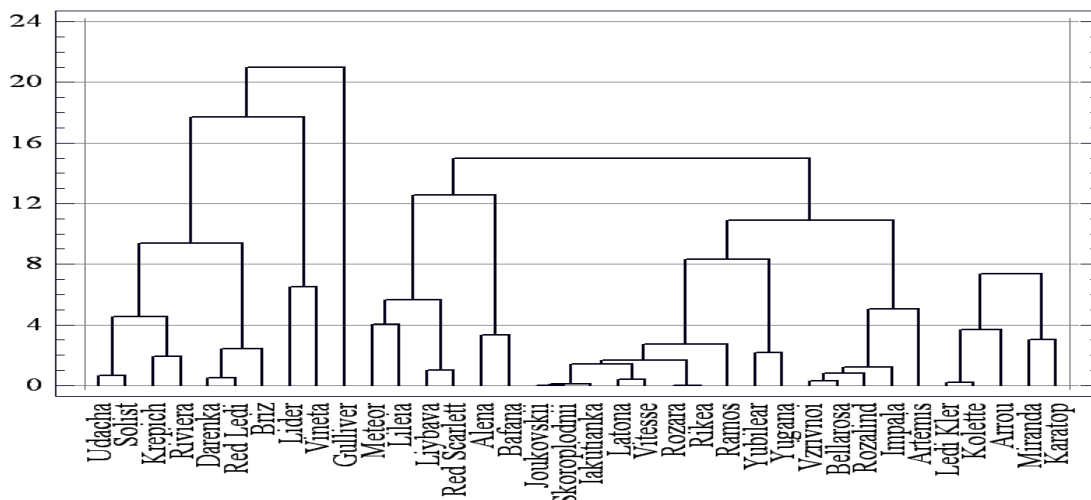


Fig.1: Grouping of early maturing varieties in the northern zone: TN - Number of tubers per plant, pcs., TY - tubers yield, g, W1 - average weight of one tuber, g

The most numerous second group (21 pcs.) Was characterized by the minimum multiplication factor, average values of plant productivity and mass of one tuber. The third group

includes 5 varieties with the lowest indicators of yield and tuber weight.

In the alpine zone, the correspondence of the distribution of

varieties into groups was confirmed by 94,44% by step-by-step discriminant analysis. The breeding coefficient and plant productivity were established as discriminators. The largest group in terms of numbers (16 pcs.) Was distinguished by the smallest mass of one tuber, average values of the

multiplication factor and potato yield (Fig. 2).

The second group of 9 varieties was characterized by higher rates of reproduction, productivity and tuber weight. The third group includes 11 varieties with the minimum values of the multiplication factor and productivity.

Indicator			
Centroids			
TN	15,1	16,8	11,7
TY	845,4	1038,6	713,5
W1	56,1	61,8	61,1

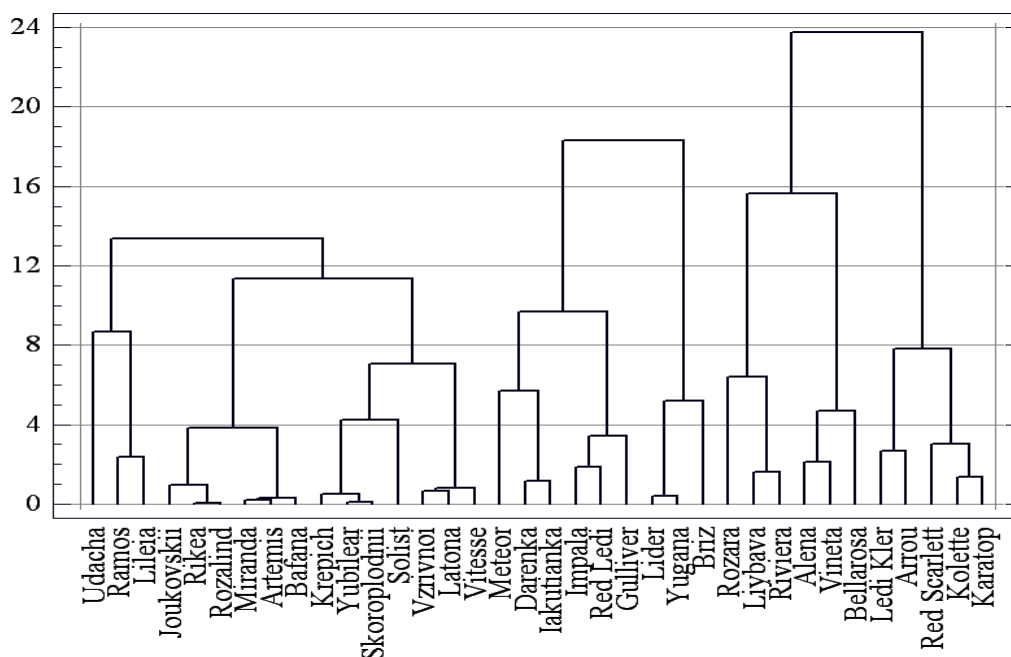


Fig.2: Grouping of early maturing varieties in the northern zone: TN - Number of tubers per plant, pcs., TY - tubers yield, g, W1 - average weight of one tuber, g

The second group of 9 varieties was characterized by higher rates of reproduction, productivity and tuber weight. The third group includes 11 varieties with the minimum values of the multiplication factor and productivity.

The results of a parallel assessment of the productivity of early-maturing potato varieties in the northern region and the high-mountain zone reflect a significant variation in yield indicators associated with the heterogeneity of environmental factors and biological characteristics of the studied potato varieties.

In the highlands, the indicators of varieties exceeded those in the northern zone: the multiplication factor was 1,9 times, the productivity of the plant was 2,4, the weight of one tuber was 1,3 times. Out of 36 early ripening varieties, only five are characterized by resistance to extreme environmental conditions in the northern and high mountain zones: Darenka, Red Lady, Breeze, Leader, Gulliver.

The relationship in the “plant - environment” system is characterized by such concepts as plasticity and stability. At the same time, plasticity is the ability of varieties to respond to changing environmental factors without significant loss of productivity. Stability is the manifestation of minor changes in the traits and properties of a particular genotype under different growing conditions.

According to the results of the assessment of the plasticity of early-ripening potato varieties out of 36 studied accessions, only in some varieties the phenotypic variability coincided. Thus, the varieties Daryonka and Impala, which respond well to the improvement of growing conditions both in the northern and alpine zones, are classified as varieties of the intensive type (with a range of bi 1,44 - 2,80). On the contrary, cultivars Zhukovsky early, Vzryvnoy, Latona, Solist (bi varied within -0,91 ... 0,81) were distinguished by a reduced sensitivity to changes in environmental conditions. Only the variety Karatop was characterized by the

coincidence of the neutral reaction of the genotype (bi corresponded to -0,06 and 0,08). Thus, in the years of research, regardless of the growing zone, none of the studied early-maturing varieties differed in the stability of the yield of tubers.

CONCLUSION

Based on the study of the interaction of the main indicators that form the structure of the yield of tubers using factor analysis, it was found that the yield of early potato varieties is directly dependent on the coefficient of plant reproduction. In the northern region and the highland zone, with an increase in the number of formed tubers, the productivity of one plant in early-maturing varieties increases, while the average weight of one tuber does not change significantly.

A grouping of varieties was carried out and the most productive genotypes were identified, which, according to a set of indicators, form the yield of tubers using cluster, discriminant analyzes. For the northern region, the most productive varieties were Gulliver, Udacha, Krepysh, Solist, Leader, Darenka, Breeze, Red Lady, Riviera and Vineta (the number of tubers per plant ranged from 8,1 to 11,4 pcs. With an average tuber weight of 37, 0 ... 67,9 g and productivity 400 ... 633 g), in the highlands - Gulliver, Yakutyanka, Yugana, Darenka, Leader, Breeze, Red Lady, Impala and Rosara (respectively 11,8 ... 19,8 pcs., 56,5 ... 70,6 g and 830 ... 1140 g).

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