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ORIGINAL ARTICLE

Ecological testing of potatoes

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The article presents the theoretical prerequisites and their experimental confirmation regarding the search for an environmental complex for the effective evaluation of the pre-breeding and breeding potato material for late blight resistance, as well as the ecological testing of varieties and hybrids. The complicated interspecies potato hybrids, their backcrosses and standard varieties were used as the starting material in the study. Late blight resistance was evaluated in the conditions of natural and artificial backgrounds, including those created in the mountain areas different in vertical zonality. The ecological testinghas been carried out in different ecological zones: southern Polissia, north-eastern Forest-Steppe, southern central Forest-Steppe, Ukrainian Carpathians for three years. Taking into account the opinion of potato scientists and on the basis of our study, the following types of ecological potato testing were identified: zonal ecological testing, specialized ecological testing, and testing in different areas by vertical zonality. It has been experimentally proved that inepiphytotic years with respect to late blight, the evaluation of the manifestation of the sign under the conditions of not only the infectious but natural backgroundis possible. However, the optimal conditions for conducting such study, conditioned by a specific environmental complex, have been created by nature in the Ukrainian Carpathians, especially at an altitude of 1330 m above sea level. While conducting the ecological testing of interspecies hybrids and their backcrosses in the three ecological zones during three years, we managed to determine the potential of the material under study with respect to productivity. The optimal conditions for the maximum productivity of hybrids were determinedin various environmental complexes: zonal, meteorological and their interrelations. The favorable conditions for 55% of hybridsturned to bethe conditions of Sumy NAU, and for ten hybrids in 2017 and one hybrid-in 2015. For nine hybrids, such conditions were found in the Institute of Potato Growing only in 2016. The environmental complex on the territory of UstymivskaExperimental Station has had a negative impact on the manifestation of the indicator. The influenceof both the specificity of the environmental complex and meteorological conditions of potato growing seasonson the hybrid productivityhas been revealed. It has been proved that by the difference in the productivity expression depending on the test area and meteorological conditions of the potato vegetation periods, 65% of the samples was more influenced by the latter set of factors.
Keywords: Environmental complex; potato; interspecies hybrids; their backcrosses; late blight resistance; productivity

Introduction

Within a historical context, the research priority has changed depending on the problems faced by mankind, the level of development of productive forces. The main achievements of scientific and technological progress in the sixteenth-eighteenth centuries were associated with the development of mechanics. In the nineteenth century, physics was the most developed, at the beginning of the twentieth century-chemistry and nuclear physics, and in recent times ecology has been far ahead (Zerkalov, 2012). This is due to the extraordinary importance of the need to address environmental problems, to establish new relationships between the components of ecosystems. Along with global problems, regional and sectoral issues, whichfurther become the components of the commonones, hold much significance.

The creation of new varieties of agricultural crops, in particular potatoes, and their prompt introduction into production are the most efficientsanitarily and hygienically safe way of increasing yield, improving its quality (Podhaietskyi, Miroshnyk, 1996). At the same time, the realization of the genetic potential of varieties by the main agronomical characters depends on the soil and climatic factors of a growing area (Dubrovin, Bayrambekov, & Korneva, 2012; Zhigadlo, 2013). It is possible to find the optimal balance between the implementation of the heredity of potato varieties and the biotic and abiotic factors of a certain region as a result of the ecological testing provided for in all breeding programs (Methodical Recommendations, 2002).

Despite the fact that potato is a highly plastic cropwidely spread on the Earth: from the polar regions to the southern latitudes of Chile, the ecological components of the external environment have a significant impact on the realization of the genetic potential of its taxonomic forms. Due to its biological properties potato requires a certain set of external factors for satisfactory growth,depending on the growth stages. For example, potato tubers awakened can withstand a short-term (up to 1 hour) temperature reduction of -9 °C (Kuchko, Vlasenko, & Mitsko, 1998). On the contrary, the above-ground mass of plants is damaged even by small frosts. However, wild species of potato growing in the mountains at an altitude of about 5 thousand meters above sea level, for example, *S. acaule Bitt.*, can withstand frosts of up to -8 °C (Horbatenko, 1990).

Plants react to temperature in a special way during vegetation. This is also due to the presence of above-ground vegetative organs and underground organs-tubers. The optimum temperature during the germination of tubers is 18-22 0C (Vlasenko, 2002). At a later stage, the maximum mass of leaves is formed at a temperature of 12-14 °C, and stems-18 °C. Flowering occurs best at a temperature of 18°C. Young tubers react to the soil temperature in a special way. The maximum yield is formed in the following conditions: early-maturing varieties at a temperature of 17 °C, and medium-maturing varieties-at a temperature of 19 °C. Higher temperatures cause ecological degeneration in tubers with the formation of filamentous sprouts. At an average daily temperature of 19-21 °C the share of such tubers in harvest is 20%, 24 °C-50, and more than 25 °C-75% (Rudenko, 1960).

Due to the fact that potato tubers contain about 75% of water (Ivaniuk, Turko, Koliyadko et al., 2007), during their formation: since buddingpotato requires a sufficient amount of moisture. On the contrary, during the germination phase the plant uses moisture reserves of planting tubers and, therefore, despite the small above-ground mass, needs very little water. Another feature of the potato is the use of tubersplanted in spring as the storage of moisture in the period of rainfall during the vegetation period of plants.

Soil is an important ecological factor for potatoes. The formation of tubers in the soil requires its high structure, porosity, and the formation of a large mass of plants-a significant supply of nutrients.

In addition to the above-mentioned,the non-regulated factors, affecting the potato growth and productivity, also include the intensity of solar insolation, the duration of light period, the degree of air saturation, wind speed, the duration of frost-free period (Kuchko, Mitsko, 1997) and some others that form an environmental complex. It is the condition that the norm of reaction of the potato samplegenotype to external conditions depends on (Podhaietskyi, Kovalenko, Horbas, Kriuchko, & Hnitetskyi, 2017).

Ecological testing is conducted in order to determine the breadth of reaction of potato hybrids and varieties to the external conditions of a certain region in the process of creating the starting breeding material, breeding new potato varieties (Nikolaev, Sezonova, Liubimskaia, Kuznetsov, & Koliadko, 2015).

The ecological testing of potatoes includes a set of activities aimed at the comprehensive evaluation of varieties, hybrids, and therefore it includes: zonalecological testing, specialized ecological testing, testing in the condition of altitudinal zonality.

According to some authors, zonal ecological testingmakes it possible to evaluate not only the productivity expression, but also the ecological plasticity of a variety, hybrid. The task of zonal ecological testing is to identify the variability of the manifestation of quantitative and qualitative characteristics under the influence of numerous environmental factors, as a result of which the selected genotypes are the most adapted to certain conditions. This enables to select varieties, hybrids with a wide normof reaction to a certain environmental complex.

A dilemma between the varieties of an intensive type and their ecological plasticity has been revealed (Bakumov, Dmitrieva, 2010). The testing of Belarusian varieties in Samara Region has resulted in the identification of genotypes of an intensive type: Dubrava, Uladar, a plastic type: Breeze, Zhuravynka, a neutral type-Lileia that is manifested in their yielding capacity, resistance to viral, fungal diseases, starch content.

The study of 20 varieties of Belarusian selection in Ural Scientific Research Institute of Agriculture of the Russian Academy of Agricultural Sciences has enabled to distinguishthe varieties which are environmentally stable by yielding capacity: Archidea, Odyssey, Lazurit, Scarb, Neptune (Shanina, 2008). In a specific environmental complex we managed to identify the following varieties not damaged by Rhizoctonia blight: Neptune, Yavar, Archidea, Lasunok, Bryhantyna, with high resistance tocommon scab: Scarb, Lasunok, Atlant, and late blight: Zhuravynka, Dina, Archidea, Hranat, Bryhantyna, Yavar, Koloryt, Lasunok, Vecktraz and Zdabytak.

Specialized ecological testing is based on the use of an environmental complex to select potato varieties, hybrids with the high manifestation of certain features. It is to a greater extent related to the definition of resistance to diseases and pests.

The Toluca Valley in Mexico is the center of the formative process and significant spread of the *Phytophthora infestans*-fungus *Phytophthora infestans* (Mont.) de Bary. Only a small number of interspecies hybrids from the N.I. Vavilov Research Institute of Plant Industry haveproved to be resistant to the fungus under these conditions (Bukasov, & Kameraz, 1972). This and similar ecological zones are extremely valuable for effective testing of breeding material.

The results of the evaluation of potato varieties in the ecologically specific conditions of altitudinal zonality have made it possible to reveal the relative contribution to the performance of ecological, hereditary and meteorological variability (Streltsova, 2008). A significant environmental effect on gene expression of the performance components has been proven. In the foothills of the Altai Mountains the most productive varieties are Horets, Belukha and Liubava, in the high mountains-the varieties of Udacha and Liubava, and in the middle mountains-Horets, Belukha and Souvenir of the Altai Mountains (Streltsova, 2008a).

The researchsimilar to the above-mentioned studieswas conducted in the conditions of the Central Zone and piedmont of Kuban. The highest yield of varieties was obtained in 2008 in the conditions of piedmont with a 2.8-time difference compared to the Central Zone (Buhaevskyi, Samodurov, Tarasnenko, Sharifulin, & Prosjatnikov, 2008).

Materials and methods

The starting material usedintheresearchisthe three-, four -, five- and six-species hybrids with the origin | [{(*S. acaule* × *S. bulbocastanum*) × *S. phureja*} × *S. demissum*] × *S. andigenum* | × *S. tuberosum* ; [{(*S. acaule* × *S. bulbocastanum*) × *S. phureja*} × *S. demissum*] × *S. tuberosum*; {(*S. demissum* × *S. bulbocastanum*) × *S. andigenum*} × *S. tuberosum*; (*S. demissum* × *S. bulbocastanum*) × *S. tuberosum*. Various commercial varieties were used for their backcrossing. The maximum degree of back crosses was the sixth-time.

The specialized ecological testing for late blight resistance was studied in the Ukrainian Carpathians with the different zonation of the experiment as the most favorable conditions in Ukraine for the disease emergence and development.

The breeding ecological testing was carried out in the two zones: the southern Polissia of Ukraine (the Institute of Potato Growing of NAAS) and the north-eastern Forest-Steppe of Ukraine (the Educational and Scientific Production Complex of Sumy National Agrarian University of the Ministry of Education and Science of Ukraine), and specialized-in the former Carpathian Reference Point of the Institute of Potato Growing of NAAS.

By the general environmental complex, the places of conducting experiments have considerably varied. The soil in the fields of the Institute of Potato Growing is sod-podzolic sandy loam with a topsoil depth of 20 cm. It is poor in humus (1.52-1.68%) and major mineral elements. The climate is temperate continental. The average multiannual rainfall amount during the potato growing season is 294 mm. The moisture resulted from rains is unequal over years, months.

The soil in the fields of the Educational and Scientific Production Complex of Sumy NAU isthe typical deep, low-humus,silty and loamy black soil. The humus content is 3.8%, pH is 5.8, the content of mineral elements is within 100 mg/kg of soil. The climate is temperate continental. The average multiannual amount of moisture resulted from rains during the potato growing season is 254 mm, but rains fall unevenly over years and months.

The soils in the Eastern Carpathians are mountain-meadow-forest and subalpine-meadow. The humus content in the arable layer is 3.5-4.5%. The soils are acidic (pH is 4.7) and well-provided with mineral nutrients. The average multiannual rainfall amount during the potato growing season is 502 mm, although they fall unevenly over years and months. Due to the terrain features, the night air temperature is relatively low, even in summer.

The environmental complex of UstymivskaExperimental Station (Ustymivka village ofHlobynskyiDistrict of Poltava Region) of the Plant Production Institute named after V. Ya. Yuriev is classified as the southern Forest-Steppe. The soils are mediumloamy and low humus (3.8%). The pH of salt extract is neutral amounting to 5.8-6.1. According to the long-term data, the precipitation amount during the potato growing season is relatively small and equal to 268 mm. The average air temperature in July and August exceeds 20 °C.

The research methodologyis common in potato growing (Metodichni, 1983, 2002). Late blight resistance has beenvisually evaluated on a 9-point scale, where the 9th pointiscorresponded to the absence of the disease signs, the 8th point-up to 10% of leaf surface is damaged by the disease, the 7th-up to 25%, the 5th-up to 55%, the 3rd-up to 80% and the 1st-more than 80% (Podhaietskyi, & Hrytsenko, 1996). The damage index of the artificially infected leaves had the following correspondence to the points and degree of resistance: 9 points-very high resistance, the damage index is 0.0-5.0; 8–high resistance, the damage index is 5.1-10.0; 7-rather high resistance, the damage index is 10.1-15.0; 5-medium resistance, the damage index is 15.1-20.0; 3-low resistance, the damage index is 20.1-30.0; 1-very low resistance, the damage index is no more than 30.0.

Results and discussion

According to our data and the data of other numerous researchers, the laboratory and field evaluation of late blight resistance of potato varieties and hybrids by no means always reflects the true nature of resistance to the fungus. One of the reasons for the above mentioned fact is the lack of a set of natural factors, underwhich an intense infection and the fungus reproduction, as well as the inability to create them in the laboratoryare observed. On the basis thereof, the most reliable data on the evaluation of resistance to the disease can be obtained in the natural environment favorable for its emergence and spread. The comparative test of interspecies hybridsand their backcrosses in the southern Polissia of Ukraine and the Ukrainian Carpathians at an altitude of 650 (Nyzhni Vorota village) and 1330 m (Plai subalpine meadow) above the sea level has been carried out to determine such place in Ukraine.

The dataobtained (Table 1) indicate a specific reaction of interspecies hybrids, standard varietiesto the manifestation of resistance depending on the evaluation methods. The conditions of the natural environmental complex of the southern Polissia zone show high resistance to the fungus of interspecies potato hybrids. The minimum value of the indicator is 7.7 points. Despite the fact that standard varieties are selected with the highest manifestation of the indicator, its value is significantly lower in comparison with hybrids, and in the variety of Nevska it is only 3 points, that is low. It can be explained by the fact that the years of conducting the researchwere epiphytoticregarding the disease,which was wide-spread even in the natural environment.

Table 1. Late blight resistance (point, index) of backcrosses of interspecies hybrids under different environmental conditions (1997-1999).

Hybrid Number	Field Origin	Institute of Potato Growing		Carpathian Reference Point			
		Background	Field ResistanceIndex	Nyzhni Vorota Village		Plai Subalpine Meadow	

		Artificial	Natural		Artificial	Natural	Natural
89.141c74	B^2six-species	8.1	8.3	21.1	7	7.3	7.5
89.202c79	B^2six-species	8.6	8	10.1	7.2	8	7.6
90.673/49	B^2three-species	8.2	8.3	18.3	8.4	8.9	8.4
90.673/75	the same	8.7	8	12.2	8.2	8.5	7.8
90.674/12	B^2three-species	7.3	7.7	12.3	7.4	8	7.3
90.691/13	B^2F_2four-species	8.3	8	24	8.4	8.9	8.2
90.730/5	B^3five-species	8.8	8.3	7.3	8.5	8.7	8.2
Nevska	standard	3	3	46.7	-	-	-
Mavka	standard	3.7	5	26.6	-	-	-
Lvivianka	standard	5	5.6	24.2	4.7	5.7	5.3
Luhovska	standard	5	5	26.8	-	-	-
Polliska Rozheva	standard	4.7	5	13.9	4.7	5.9	4.7

The data obtained show that the environmental complex of the natural infectious background is almost on a par in pathogenic properties with the artificial one, which is distinguished not by the occurrence of the natural infection, but by its application to the plant grown in the laboratory. In separate interspecies hybrids such as 89.202c79, 90.673/75, 90.691/13 and 90.730/5, the relationship between the ecological environment and genotype in the conditions of artificial infectious background in comparison with the naturalone have turned out to be more favorable for the manifestation of resistance expressed in the highest point of resistance.

Other results were obtained in the conditions of the environmental complex of the Carpathians, especiallythe natural background of the Plai subalpine meadow. With the exception of hybrid 90.673/49, others have shown lower late blight resistance than on other test sites. For example, in hybrid 90.673/75, the difference in the test data in the conditions of artificial infectious background of the southern Polissia zone is 0.9 points. The same is related to the standard variety of Lvivianka in the conditions of artificial infectious background in both ecological zones, however, the same data have been obtained regarding the variety of Polliska Rozheva.

In contrast to the standardvarieties, some interspecific hybrids and their backcrosses, even due tothe ecological testing for late blight resistance in the Carpathians, have no signs of the disease, or show high resistance (Table 2).

Table 2. Late blight resistance (in points) of interspecies hybridsand standard varieties in environmental complexes of the Carpathian zonal areas.

Variety, hybrid	Artificial background (Nyzhni Vorota Village)					Natural background									
						Nyzhni Vorota Village					Plai Subalpine Meadow				
	1998	1999	2000	2001	average	1998	1999	2000	2001	average	1998	1999	2000	2001	average
Polliska Rozheva	3.7	4	5.3	3	4	5	3.3	6	3	4.3	4.3	3	5	3	4
Lvivianka	4	4.3	5	3.7	4.3	5.3	3.3	5.7	3.7	4.5	4.7	3.3	5	3	4
Hitte	3	3.7	4.3	2.3	3.3	4.3	3.3	5	2.3	3.7	3.7	2.3	3.7	1.7	2.9
Volovetska	4.7	5.3	6	3.7	4.9	6.7	4.3	7	3.7	5.4	5.3	3.3	5.7	3.3	4.4
89.24c34	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.666/3	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.674/13	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.676/6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.694/7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.675/27	7.3	6.7	7.7	6.3	7	7.7	6.7	7.7	6.3	7.1	7.7	6.7	7.3	5.7	6.9
90.675/31	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.675/34	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
90.675/36	8	8	8	7.3	7.8	8.3	8.3	8.3	7.3	8.1	8	7.3	8	6.7	7.5
91.357-14	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

It has been found that by the testing intensity for standard varieties the conditions of artificial infectious background ofNyzhni Vorotavillageis inferior to the natural background of Plai subalpine meadow, although with a small difference of 0.3-0.5

points, and only in the variety of Polliska Rozhevano difference in the sign manifestation depending on the test sites has been found. At the same time, the comparison of the effectiveness of evaluation of late blight resistanceof standard varieties in the conditions of natural infectious background indicates that in Nyzhni Vorota village they show a low resistance to the fungus in comparison with the conditions ofPlai subalpine meadow. The difference in the sign manifestation is in the range of 0.3-1.0 points.

Despite the favorable environmental complex for the manifestation of resistance in the conditions of the natural infectious background of Plai subalpine meadow, numerous backcrosses of interspecies hybrids have no signs of the disease, and in others the sign manifestation is quite high. It is the specialized ecological testing that has made it possible to reveal high breeding value bylate blight resistance of the 90.765 offspring obtained from the crossing of one-off backcrossof the three-species hybrid with the variety of Nemishaevska 10. Among the four hybrids being tested, the two ones have shown very high resistance, and the other two –relatively high or high. The opposite has concerned the combination 90.666 (Table 3). Among its four hybrids being tested, only one has shown very high resistance. Two of them have shownhigh resistance, and one-relatively high resistance. It is the specialized ecological testing that has enabled to reveal the differences between the materialsstudied by the sign. In the conditions of the southern Polissia there is no difference between them.

A high correlationof the manifestation of resistance during testing underthe conditions of the artificial and natural infectious backgrounds in Nyzhni Vorota village has been revealed. The value of the correlation coefficient is +0.97. The correlation coefficient (+0.98) is even higher between resistance in the conditions of natural infectious background in Nyzhni Vorota village and Plai subalpine meadow,and the artificial infectious background ofNyzhni Vorota village and the natural one in the conditions of Plai subalpine meadow.

At the same time, the disturbance of the ecological balance on the test sites mainly due to the variability of meteorological factors has caused a difference in the variation of resistance over years (Table 3). Among the standardvarieties the greatest value of the variation coefficient is observed in the conditions of natural infectious background in Nyzhni Vorota village. The exception is the varietyof Hitte, in which the above mentioned occurin Plai subalpine meadow.

Table 3. Variation (V, %) of late blight resistance depending on an environmental complex and the evaluation methods.

Variety, hybrid	**Artificial background(Nyzhni Vorota Village)**			**Natural background**					
				Nyzhni Vorota Village			**Plai Subalpine Meadow**		
	$\overline{X}$	**σ**	**V, %**	$\overline{X}$	**σ**	**V, %**	$\overline{X}$	**σ**	**V, %**
Polliska Rozheva	4	0.96	24.1	4.3	1.42	33.1	4	1	24.9
Lvivianka	4.3	0.56	12.9	4.5	1.18	26.2	4	1	24.9
Hitte	3.3	0.87	26.2	3.7	1.18	31.9	2.9	1	34.9
Volovetska	4.9	0.97	19.9	5.4	1.67	30.9	4.4	1.3	29.1
90.675/27	7	0.62	8.9	7.1	0.71	10	6.9	0.9	12.6
90.675/36	7.8	0.35	4.5	8.1	0.5	6.2	7.5	0.6	8.4
88.1450c2	7.6	0.29	3.9	7.8	0.29	3.7	7.4	0.2	2.3
89.141c74	7.4	0.65	8.8	7.6	0.62	8.2	7.1	0.6	8.7
89.24c57	7.8	0.29	3.7	7.6	0.53	7	7.5	0.4	5.1
90.666/4	8	0.41	5.1	8.1	0.51	6.3	7.8	0.3	3.7
90.666/25	7.6	0.44	5.8	7.7	0.44	5.7	7.8	0.3	3.7
90.666/13	8.2	0.15	1.8	8.4	0.17	2.1	8.2	0.1	1.6
90.666/3	9	0	0	9	0	0	9	0	0

Another, with respect to the above, is observed in respect of hybrids. The same frequency of the maximum expression of the variability coefficient (three hybrids) is observedin the natural infectious background in Nyzhni Vorota village and in the artificial one under the same conditions, and onlytwo hybrids have the greatest variation of the sign manifestation in the environmental complex of Plai subalpine meadow. The above mentioned suggests a specific interaction of the external complex and the genotypes of the material under study in relation to the manifestation of late blightresistance that is to be taken into account in the evaluation of varieties and hybrids.

The zonal ecological testing of 20 interspecific hybrids and their backcrosses was carried out in Sumy National Agrarian University, the Institute of Potato Growing and UstymivskaExperimental Station. The data obtained (Table 4) indicate a specific reaction of hybrids to the growing conditions on each of the test sites. We have managed to determine the potential of the studied material by maximum productivity. The best conditions for its manifestation wereobserved in SNAU in 2017. The hybrids88.1450c3, 89.715c88, 901.35c131 and 08.187/13 of the above mentioned environmental complex have formed more than 1000 g of tubers expressed in terms of a nest with the maximummanifestationof the indicator in the hybrid 90.35c131-1300 g.The high potential of the hybrid 89.715c88 was also confirmed during its testing in the conditions of the Institute of Potato Growing in 2016. We believe that the above mentioned indicates a high probability of realization of the hybrid genetic potential in different environmental conditions that makes it valuable for use in practical breeding.

Table 4. Productivity (g/nest) expression ininterspecieshybrids depending on anenvironmental complex.

Hybrid	Test Site	Year			Average	Difference	σ	V, %
		2015	2016	2017				
88.1450c3	SNAU	227	250	1100	526	873	498	95
	Institute of Potato Growing	154	639	240	344	485	259	75
	Ustymivska Experimental Station	329	19	183	177	310	155	88
	Average	237	303	508	349	563		
	Difference	175	620	917		742		
89.202c89	SNAU	234	417	900	517	666	344	67
	Institute of Potato Growing	190	700	361	417	510	224	48
	Ustymivska Experimental Station	524	411	591	509	180	91	18
	Average	316	509	617	481	486		
	Difference	334	289	539		250		
89.715c88	SNAU	450	367	1133	650	766	420	65
	Institute of Potato Growing	300	1258	300	619	958	553	89
	Ustymivska Experimental Station	275	125	330	243	205	106	44
	Average	342	583	588	504	753		
	Difference	175	1133	833		958		
90.35c131	SNAU	240	200	1300	580	1100	624	108
	Institute of Potato Growing	236	713	300	416	477	259	62
	Ustymivska Experimental Station	230	298	327	285	97	50	17
	Average	235	404	642	427	1003		
	Difference	10	513	1000		990		
90.673/30	SNAU	850	143	567	520	707	356	68
	Institute of Potato Growing	200	717	244	387	517	287	74
	Ustymivska Experimental Station	302	125	216	214	177	89	41
	Average	451	328	342	374	530		
	Difference	650	460	351		299		
90.691/9	SNAU	500	425	498	474	75	43	9
	Institute of Potato Growing	250	715	338	434	465	247	57
	Ustymivska Experimental Station	386	44	153	194	342	175	90
	Average	379	395	330	367	390		
	Difference	250	671	345		326		
90.729/14	SNAU	233	350	200	261	150	79	30
	Institute of Potato Growing	205	631	292	376	426	225	60
	Ustymivska Experimental Station	345	113	421	293	232	160	55
	Average	261	365	304	310	276		
	Difference	140	518	221		378		
08.187/13	SNAU	527	300	1256	694	956	499	72
	Institute of Potato Growing	244	804	343	464	560	299	64
	Ustymivska Experimental Station	567	313	520	467	254	135	29
	Average	446	472	706	542	702		
	Difference	323	504	913		590		
08.194/20	SNAU	356	699	869	641	513	261	41
	Institute of Potato Growing	460	813	420	564	393	216	38
	Ustymivska Experimental Station	332	500	436	423	168	85	20
	Average	383	671	575	543	345		
	Difference	128	313	449		321		

By the diversified environmental complex: zonal and meteorological, and their interaction,we have managed to identify the reaction of each hybrid studied to the above-mentioned conditions through maximum productivity. For 55% of hybrids, the best conditions for the realization of genetic potential by the signhave turned to be in SNAU. For 10 hybrids such conditions

were during the potato growing season in 2017, and for the hybrid 90.673/30-in 2016. For other nine hybrids, the highest productivitywasobserved in the conditions of the Institute of Potato Growing only in 2016. None of hybrids have maximum productivity in Ustymivska Experimental Station that suggests that in this environmental complex they are relatively worse for the productivity expression.

We have determined the optimal environmental complex for productivity of hybrids depending on the meteorological conditions of the years of conducting the experiment. In the conditions of SNAU, the maximum realization of the potential of hybrids by the signoccurred in 2017 (85%). Two hybrids had such characteristics in 2015 (10%) and onehybrid in 2016. In the conditions of the Institute of Potato Growing, all hybrids had maximum productivity in 2016. The largest share of the studied material amounting to 65% realized its potential in the conditions of Ustymivska Experimental Station in 2015. In 2017, there were four such hybrids-20% and three in 2016.

The influence of the environmental complex on the productivityexpression has been analyzed as well. During all years no hybrids with low productivity (up to 300 g/nest) were found in the conditions of SNAU. The average manifestation of the indicator (300.1-500.0 g/nest) is observed in 20% of hybrids, the increased manifestation (500.1-700.0 g/nest)- in 15%, the high manifestation (700.1-900.0 g/nest)-in 40%, and very high (more than 900 g/nest)-in 25%. The environmental complex of the Institute of Potato Growing has turned to be somewhat worse for high productivity. Only one hybrid (89.715s88) has very high productivity. Half of the estimated hybrids are characterized by high manifestation of the sign, 35%-by increased manifestation,and two hybrids– by average manifestation. The least favorable conditions for the implementation of the genetic potential of hybrids by productivity are in Ustymivska Experimental Station. Only 20% of their total number ischaracterized by the increased manifestation of the indicator. The maximum share of material amounting to 55% has average productivity. Only under these conditions hybrids show low productivity– less than 300 g/nest thatis five samples or 25% of their total number.

The analysis has been made to determine the same reaction of hybrids with the maximum manifestation of the sign. Only four types of combining the environmental conditions favorable for productivity have been identified. The maximum number of samples (55% of the total number) was characterized by the highest manifestation of the indicator in the conditions of SNAU in 2017, the external complex of the Institute of Potato Growing in 2016, and the conditions of Ustymivska Experimental Station in 2015. The three hybrids, including 89.202c89, showed the above mentioned feature in SNAU and Ustymivska Experimental Stationin 2017, and in the Institute of Potato Growing in 2016. Another three hybrids, including 08.194/20, had the samein SNAU in 2017, and in Ustymivska Experimental Stationand the Institute of Potato Growing in 2016. For the two hybrids, in particular 90.673/30, the optimal environmental complex for the maximum productivity expression was characterized by the following combination: year– test site: the conditions of SNAU and Ustymivska Experimental Stationin 2015, and the conditions of the Institute of Potato Growing in 2016. For one hybrid (90.729/14), the above was manifested in the conditions of SNAU and the Institute of Potato Growingin 2016,and Ustymivska Experimental Station in 2016.

The value of the impact of meteorological conditions of the year and site of the study on the expression of productivity has been determined. For this purpose, the difference in the manifestation of the sign depending on external conditions has been compared. The calculations have shown that the majority of hybrids (65% of the estimated)in a greater degree have responded to changes in the meteorological conditions during the year of testing. For the rest, the prevailing difference value was due to the conditions of the test sites.

The influence of variability of meteorological conditions on the productivity expression during the years of conducting the experiment has been determined. Only one hybrid (90.691/9)is characterized by relative stability of the productivity expression depending on the conditions of the vegetation periods of 2015-2017, and this is only related to SNAU. The comparatively low value of the coefficient of variation is observed in the hybrid 90.690/7 in SNAU, and the hybrids 89.202s89 and 90.35s131 in Ustymivska Experimental Station. It is important that the samples 90.690/7 and 89.202s79 have had stable increased productivity, and the hybrid 90.35s131– stable low productivity.

Conclusions

The environmental complex favorable for the appearance and spread of late blight in the epiphytotic years in the southern Polissia of Ukraine enables to evaluate the resistance to the fungus of interspecieshybrids, their backcrosses in terms of the natural background without using the infectious one. At the same time, most varieties tested in the natural background have higher resistance to the fungus than in the artificial one.

It has been proved that the environmental complex of the Ukrainian Carpathians, especially the higher zonality (1330 m above sea level) enables to efficiently evaluate late blight resistance in the natural conditions, even in comparison with the artificial background on the lower (650 m above sea level) altitude level.

Despite different backgrounds and zonality, individual interspecieshybrids and their backcrosseshave not been damaged by late blight over the four years of research that makes them especially valuable for practical breeding use as an effective factor in obtaining environmentally friendly products.

The greatest variation of late blight resistance is found in varieties during the evaluation under conditions of the natural infectious background in Nyzhni Vorota village (650 m above sea level). With respect to hybrids, the above mentioned with the same frequency is observed in the artificial and natural infectious backgrounds in Nyzhni Vorota village. To a lesser extent, the above is related to the testing at thealtitude level of 1330 m above sea level.

The ecological testingconducted in various areas for the three years has enabled to identify the potential of potato

interspecieshybrids andtheir backcrossesby productivityamounting up to 1258 g/nest under the favorable external environment conditions. By the diversified environmental complex: zonal and meteorological, and their interaction, we have managed to identify the reaction of each hybrid studied to the above-mentioned conditions through maximum productivity. For 55% of hybrids, the best conditions for the realization of genetic potential by the sign have turned to be in SNAU. For 10 hybrids such conditions were during the potato growing season in 2017, and for the hybrid 90.673/30-in 2016. For other nine hybrids, the highest productivity is in the conditions of the Institute of Potato Growing only in 2016. None of the hybrids has maximum productivity in Ustymivska Experimental Station that suggests that in this environmental complex they are relatively worse for the productivity expression.

The influence of meteorological conditions as a component of the environmental complex on the expression of productivity of interspecieshybrids and their backcrosseshas been proved. In the conditions of SNAU, the maximum realization of their potential by the signwas observed in 2017 (85%). The two hybrids had such characteristics in 2015 (10%) and one hybrid in 2016. In the conditions of the Institute of Potato Growing, all hybrids had maximum productivity in 2016. The largest share of the studied material realized its potential in the conditions of Ustymivska Experimental Station in 2015-65%. In 2017, there were four such hybrids-20% and three in 2016.

It has been proved that the value of the productivity expression is influenced by both the specificity of ecological zones and meteorological conditions. For the maximum share of hybrids with very high productivity and low manifestation of the indicator, the best conditions for the realization of the sign were in SNAU-55% of samples with very high productivity, most of which had such characteristic in 2017.

It has been revealed that by the difference in the productivity expression depending on the test site and meteorological conditions of the potato vegetation periods, 65% of the samples was more influenced by the latter set of factors.

The relative stability of the productivity expression, depending on the environmental complex, is revealed only in some hybrids. The minimum value of the variation coefficient amounting to 9% was identified in the backcross 90.691/9 during the testing conducted in the outer complex of SNAU. The value of the hybrid is also close to the higher expression of the indicator.

References

Kuchko, A. A., Vlasenko, M. Y., & Mitsko, V. M. (1998). Physiology and biochemistry. Kyiv. Dovira, p: 335 (in Ukrainian).

Horbatenko, L. E. (1990). The catalyst is a collecting factor for VYR. South American Potato types (sektsyia Petota Dumort. roda Solanum L.). Lenynhrad, Vip. 569, 398 (in Russian).

Kuchko, A. A., & Mitsko, V. M. (1997). Physiological bases, shapes and strengths. Kyiv. Dovira, 142 (in Ukrainian).

Podhaietskyi, A. A., Kovalenko, V. M., Gorbas, S. M., Kriuchko, L. V., & Gnitetskyi, M. O. (2017). The reaction norm of the khenotopic of the middle-sized ones, carts on the drain of the forest in the beer-shidny Forest-Steppe of Ukraine for the productivity and storage. Visnyk Sumskoho NAU. Seriia Ahronomiia i biolohiia, 2(33), 155-160 (in Ukrainian).

Vlasenko, M. Y. (2002) Morphology, physiology, and biochemistry. Kartoplia, T1, 54-115 (in Ukrainian).

Ivanyuk, V. G., Turko, S. A., & Kolyadko, I. I. (2007). Tabletop potato grower. Mynsk. Reiplats,126 (in Russian).

Rudenko, A. I. (1960) Climatic degeneration of potatoes and measures to combat it. Potato seed issues and the fight against echo degeneration. Kyev, 28-44 (in Russian).

Zerkalov, D. V. (2012). Environmental safety and environmental protection. Kyiv. Osnova, 514 (in Ukrainian).

Podhaietskyi, A. A., & Miroshnik T. G. (1996). Vikoristannia environmentally safe method of combating potato nematode. Naturalis, 1996, 1, 7-9 (in Ukrainian).

Dubrovin, N. K., Bayrambekov, Sh. B., & Korneva, O. G. (2012). Productivity of domestic potato varieties in the Astrakhan region. Potatoes and Vegetables, 1, 19-20 (in Russian).

Zhigadlo, T. E. (2013). Promising potato varieties for the Murmansk region. Potatoes and Vegetables, 4, 25-26 (in Russian).

Methodical recommendations are made by drawing up the map. (2002). Nemishaeve, 183 (in Ukrainian).

Nikolaev, A. V., Sezonova, N. P., Lyubimskaya, I. G., Kuznetsov S. S., & Kolyadko, I. I. (2015) Ecolonic sprouting of Belarusian potato varieties in the conditions of the Kostroma region. Angar science of Euro-Northeast, 1(44), 14-17(in Russian).

Bakumov, A. L., & Dmitrieva, N. N. (2010). Characteristic of Belarusian varieties of potato complex economically valuable traits, Environmental plasticity and stability in the conditions of the Samara region. Kartofelevodstvo, sb. nauchn. tr. RUP. Scientific and Practical Center of the National Academy of Sciences of Belarus for Potato, Vegetable and Fruit Growing. Mynsk, 2008(in Russian).

Shanina, E. P. (2008). The study of potato varieties of Belarusian breeding in the middle of the Urals. Potato growing, Sat. scientific tr. RUP Scientific and Practical Center of the National Academy of Sciences of Belarus for Potato, Vegetable and Fruit Growing. Mynsk, 2010, 17, 5-11 (in Russian).

Streltsova, T. A. (2008). Echolohycheskaia trait variability potatoes in different lateral zones the district of Hornoho Altaia. Avtoref. dokt. dys. 03.00.16- Ecolohyia. Novosybyrsk, 44 (in Russian).

Streltsova, T. A. (2008a). Echolohycheskaia trait potato varieties productivity in different vertical conditions the Altai Mountains. Kartofelevodstvo: research result, innovation, practical experience. Moskva, 2008, 2, 190-198(in Russian).

Bukasov, S. M., Kameraz, A. Ya. (1972) Selection of potato seed. Lenynhrad: Kolos, 1972, 358 (in Russian).

Bugaevsky, V. K., Samodurov, V. N., Taranenko, V. V., Sharifulin, R. S., Prosjatnikov,J. G. (2008). Testing varieties of Belarusian breeding in the Kuban. Potato growing: research result, innovation, practical experience. Moskva, 2, 12-19(in Russian).

Guidelines for conducting research with potatoes. (1983). Kyev, 216(in Ukrainian).

Podhaietskyi, A. A., Gritsenko, K. P. (1995). Assessment of a wick-heartedly wicked-wisely selected sci-inono material for stiikist

anti-chromic aloe (Methodical recommendations). Kyiv, UAAN, IK, 56(in Ukrainian).

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