RESULTS OF NEW TRENDS OF POTATO BREEDING PROGRAMS DEVELOPED IN RUSSSIA

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ABSTRACT

The article presents the results of introgression of valuable genes from wild and cultivated species of *Solanum* and varieties of the world collection (CIP) to selection varieties in the production of backcross hybrids, selection of recombinants in backcross generations and in offspring from crossbred crosses among themselves, as well as special parent lines for implementation of programs in various areas of potato breeding. Studies were conducted to determine the effectiveness of different types of crossing during backcrossing in the frequency of occurrence of recombinant forms with high rates of polygenic traits in the hybrid progeny. Hybrids-backcrosses for immunity to virus Y, field resistance to late blight and resistance to the pathogen Ro1 of the golden potato nematode were evaluated by the method of artificial infection in pot-plant in a greenhouse. Analysis of hybrid progeny for starch content and suitability for processing by the color of chips was carried out under laboratory conditions. According to the results of the analysis of the pedigrees of 10 varieties of potato originating from the two forms of *S. chacoense*, a high efficiency of recurrent accumulation crosses providing introgression of the dominant immunity genes to the virus Y is revealed, as well as resistance to alternaria, heat and drought. Medium-late varieties with high field resistance of leaves and tubers were created on the basis of unstable to the late blight hybrid (F_1 *S. chacoense 55 d x Agra*) and 3 recurrent crosses. In this case, varieties with medium field resistance to late blight participated in backcrossing. When assessing the collection of wild species for resistance to the pathogen Ro1 of the golden potato nematode, only one new source of *S. chacoense* 58 d was detected. Analysis of the cleavage in resistance to nematode among populations from the crossing of three-species hybrids *(vrn x chc) x tbr* and backcross hybrids *(vrn x chc) x tbr*^{2} confirmed control of the trait by one dominant gene, which facilitates selection for this feature. Based on the analysis of the frequency of occurrence of hybrids with different starch content in the fissile offspring, it is established that this feature is controlled by a small amount of pure additively acting genes. In the hybrid populations studied, the symmetrical frequency distribution, the presence of transgressions, and the high correlation between the average starch content of parental forms and the average offspring were observed. In a comparative assessment of 36 hybrid populations on the suitability for processing for potato products, methods for selecting parental forms for crossing and timing of the evaluation of the trait in different periods of tuber storage have been identified. Twenty-two hybrids are identified that are suitable for processing during the entire storage period without reconditioning. An increase in the efficiency of the selection process was noted in the repeated use of identical hybrid populations for selection in various environmental and geographical conditions, which significantly reduces the financial costs of creating a variety.

Keywords: potato, selection, wild species, backcrossing, field stability, immunity, inheritance, cleavage,.

نتائج اتجاهات حديثة لتطوير برامج تربية البطاطا في روسيا

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المستخلص

يهدف البحث للحصول على بعض النتائج الحديثة من برامج التربية المتطورة للبطاطا في روسيا، اجراء تضريبات مختلفة منها التضريبات الرجعية والتضريبات المتكررة والحصول على زيادة في كثير من صفات البطاطا. من نتائج التجارب لانساب 10 اصناف من البطاطا يغود اصلها الى طرازين و كانت هنالك كفاءة عالية لتراكم التضريبات التكرارية المذكورة في اظهار الجينات السائدة لصفة الحصانة للفايرس Y للنسل المستنبط من التربية الداخلية بالاضافة الى المقاومة للالتناريا وللجفاف وللحرارة. تمت استنباط اصناف متوسطة الى متأخرة ذات مقاومة حقلية عالية للاوراق و للدرنات من اساس هجين غير مستقر للفحة المتأخرة، وثلاث من التضريبات المتكررة وفيها تم استنباط اصناف لهل مقاومة حقلية متوسطة للفحة المتأخرة من التضريبات الرجعية. تمت التحاليل لمقاومة النيماتودا بين مجتمعات من هجن ثلاثية والهجن الرجعية التي اكدت سيطرة زوج من الجينات السائدة على هذه الصفة.

كلمات مفتاحية: تربية، تضريبات، نتأئج، فايرس

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INTRODUCTION

Modern development of selection of potato varieties for a specific purpose using various methods of selecting breeding components and selecting economically valuable hybrids during the field trial provides for an increase in the level of resistance to the most harmful pathogens (1). It is known that for the main breeding directions there are actually parental forms derived from wild species in interspecies hybridization with cultural forms using natural sources of stability. Such parental forms, which have genes of wild species, contribute to increasing heterozygosis, developmental capacity and productivity of hybrid progeny. Moreover, many wild and cultivated species are not only sources of resistance to pathogens, but also differ in the high content of starch and protein in tubers (2, 12). Despite the successes achieved, the problem of introgression of foreign genes was not sufficiently studied. Only the first stages of this process, including obtaining interspecific hybrids and the overall results of backcrossing, have been thoroughly studied. In this case, promising breeding hybrids are allocated after 3-6 recurrent crossings, depending on the genetic characteristics of wild species and the selection of varieties for getting backcrosses (4, 5, 6). In this regard, the aim of the work is to study the effectiveness of different types of crossing during backcrossing on the frequency of occurrence of recombinant forms with high rates of polygenic traits in the hybrid progeny.

MATERIALS AND METHODS

Hybrids-backcrosses on immunity to the virus Y were evaluated by the method of artificial infection of seedlings at the age of 3-5 true leaves (mechanical rubbing, visual diagnostics and on indicator plants, repeated inoculation with vaccination on infected tomato). Stable samples were grown in a potted plant in a greenhouse, then the backcross hybrids were maintained on a vegetation site or in greenhouses for use in repeated crossings (7). Field trials of the Backcross hybrids were carried out according to the hybrids scheme II year in the first year of evaluation and according to the preliminary testing scheme - in subsequent years. For resistance to viruses, hybrids were visually assessed in the field during flowering. To test externally healthy plants, the EIA method was used to covert infection with viruses. Field resistance to late blight was determined by artificial infection, using a well-known laboratory-field method of inoculation of individual leaves taken from plants in the field during flowering. For inoculation, the highly virulent 1.2.3.4.5.6.7.8.9.10. XYZ increased aggression race was used. The infectious load was 25 conidia in the field of sight of the 120-power microscope. The degree of invasion was assessed on a 9-point scale according to the infection of three leaves with three leaves. The average score of the lesion was calculated by the parameters of two counts - 3 days after inoculation and 5-6 days after first count (8). Stability of the tubers was determined two months after harvesting by infecting whole tubers under laboratory conditions. Laboratory tests of the resistance of the selection material to the pathogen Ro1 of the golden potato cyst-forming nematode were carried out using an improved evaluation technique (10). The starch content in tubers of hybrids was estimated 30-40 days after harvest by specific weight. The suitability of the samples for processing was evaluated by the color of the chips on a 9-point scale on a laboratory microline (11). During the harvesting period, the samples resistant to viral diseases and late blight were evaluated on the basis of the compactness of the nest, the shape of the tubers, the depth of the ocelli, the length of the stolons, and the yield (weighing). The effectiveness of backcrossing options was assessed by the indicators of new varieties created on their basis. To do this, we analyzed the origin of the varieties and the types of crossings that were used in each generation of backcrosses.

RESULTS AND DISCUSSION

Breeding of Cultivars Resistant to Viruses The most harmful potato virus in Central Russia, where the climate is rather continental, is *Potato virus Y* (PVY), which causes potato degeneration, especially in the case of mixed PVY - *Potato virus X* (PVX) infections. The main objective of our study was to find and isolate suitable sources of resistance to PVX and PVY. The wild species collection was examined for resistant forms using artificial infection of seedlings obtained by the standard

self-fertilization technique. Resistance to PVY^0 was found for two genotypes of the diploid *Solanum chacoense* species (2n=24), which demonstrated the presence of a dominant gene after segregation analyses in the F_1 and several backcross progenies (16). The characteristics of these sources, the breeding scheme and the selection results are shown in Table 1. When introducing these resistances through crossings using the *S. chacoense* accessions 55d and 58d, we obtained autotetraploids and amphidiploids, respectively. We found and isolated three sources of resistance to PVY obtained by the self- fertilization of several backcrosses carrying the R_{Ysto} gene (F_2B_n). The seeds were provided by N.W. Simmonds (UK) in 1975. Resistant genotypes were detected using artificial infection of seedlings (mechanical inoculation, grafting on tomato and diagnostics with the help of indicator plants) and the field evaluation of the tuber generation. Three five-species hybrids, immune to PVY, PVX and *Potato virus S* and resistant to *Potato leafroll virus*, were obtained from S. Sharvari (Hungary). Cv. Fanal, containing the R_{Ysto}, gene, was used as an additional source of resistance to PVY. Cv. Safir, containing the R_{Xacl} gene, was used as the source of resistance to PVX. Table 1 shows that the total number of cultivars, bred on the basis of these sources, was 31, and 21 of them have been included in the State Register. The evaluation of backcross generations allowed us to obtain new data on the breeding value of these sources.

Table 1. Characteristics of different sources for viral resistance and results of their use in the Russian potato breeding programme

Source of resistance and its genotype	Breeding scheme	Number of backcross generations	Cultivars isolated		The most widespread cultivars
			Total	Registered in the State Register	
***Solanum chacoense f. garciae* 55d (2n=24) R_{Ychc}**	**Autotetraploids (2n=48) F_1 hybrids (chc x tbr)**	**3**	**6**	**4**	**Nikulinskiy, Utenok**
***S. chacoense f. commersanii* 58d (2n=24) R_{Ychc}**	**Amphidiploids vrn x chc (2n=48) Three-species hybrids ($3F_1$)**	**2**	**5**	**4**	**Bryanskiy delicates, Nakra**
Progeny of selffertilized backcrosses of *S. stoloniferum* R_{Ysto}	**(Generation F_2B_n) F_2B_n x tbr**	**3**	**8**	**4**	**Golubizna, Ramzai, Effekt**
Five-species hybrids (tbr-acl-adg-dms-sto) R_{Ysto} R_{Xacl} R_{Sadg}	**Hybrid-cultivar crossing**	**1**	**6**	**5**	**Resurs, Kolobok, Yubilei Zhukova**
Fanal R_{Ysto}	**Crossing with cultivars**	**2**	**4**	**2**	**Lira, Zhigulevskiy**
Saphir R_{Xacl}	**Crossing with cultivars**	**2**	**2**	**2**	**Goryanka**
Total			**31**	**21**	**14**

The progeny of the Hungarian hybrids and *S. chacoense* 55d and 58d was resistant to early blight and the hot and dry weather conditions. Several lines, originating from 55d, were considerably resistant to Colorado potato beetle (cvs. Peresvet and Nikulinskiy). We also isolated three highly fertile genotypes (15c-11, 128-6, 80-1) among the backcross progenies, obtained by self-fertilization of the English sources and the progeny of cv. Fanal. Such high fertility is atypical for the carriers of the R_{Ysto} gene. In all cases we used pollinators with high pollen fertility (Beryozka and Smena). Backcross 128-6 was the most valuable and was used to obtain several PVY-resistant cultivars. This backcross is now widely used in the breeding program. The use of the autotetraploid *S. chacoense* 55d (2n=48) for breeding new cultivars required three backcross generations. The whole breeding cycle took 18 years (1986-2004). In the case of the amphidiploid *S. vernei x S. chacoense* (2n= 48), we performed two backcrosses, and the whole breeding cycle took 23 years (1987-2010). In the case of backcrossing different F_2B_n sources obtained by self-fertilization, we required one to three backcrossings. The use of the late-blight resistant cv. Beryozka increased both the number of backcross generations and the level of late-blight resistance in the progeny. The whole breeding cycle, including three backcross generations, took 17 years (1985-2002). Thoroughly selected Hungarian hybrids produced new cultivars in the first

generation of all crossings. In the case of cv. Fanal we selected valuable genotypes only in the second generation. The cultivars and hybrids we obtained from different PVY-resistant sources are widely used now for different breeding tasks, increasing the genetic diversity and heterozygosity of the breeding material. To date we have bred several cultivars carrying resistance genes from the different sources we have used: Veteran (chc-sto-sto), Russkiy Suvenir (chc-sto), etc. Slava Bryanschiny harbours genes from six different species: five wild species plus *S. tuberosum ssp. andigena. Breeding of Cultivars with Increased Field Resistance to P. infestans*This type of breeding started on the basis of a study of the inheritance of field resistance. In 1985 (during an important epidemic) we performed a field evaluation of the first tuber generation of r-genotypes. We showed that field resistance is controlled by additively acting polygenes as determined by transgressive progeny segregations and found an intermediate level for the inheritance of this property (4). The type of inheritance detected determined also our basic breeding methods: crossings with resistant partners to accumulate resistance genes (saturation crossings) and selection of transgressive recombinants (TR hybrids), which combined high field resistance with various economically interesting characteristics. To identify TR hybrids, wc used artificial inoculution of detached leaflets with the highly virulent *P. infestans* race 1.2.3.4.5.6.7.8.10 XYZ, annually obtained from the Russian Research Institute of Phytopathology. The infection load was 25 conidia per microscopic field (x 120). The efficiency of saturation crossings was tested experimentally during the backcrossing of PVY-resistant hybrids. Using the non-resistant F_1 hybrid (*S. chacoense* 55d x Agra), we performed three backcrossings and bred new middle- late cultivars (Nikulinskiy and Bryanskiy nadezhniy) with high field resistance of tubers and leaves. Both cultivars were also PVY-resistant. For the backcrosses we used cultivars with average (Kameras, Dekama) and high (Mavka, Zarevo) field resistance. All these cultivars carry genes from *S. demissum.* Similar results were obtained during the breeding of cv. Nakra. After backcrossing of the non-resistant three-species hybrid ((*S. vernei x S. chacoense* 55d) x Anoka) with two resistant late-maturing cultivars (Bison, Zarevo), we obtained a mid-ripening cultivar with a high field resistance to *P. infestans*. These data show that two to three saturation backcrosses accumulate sufficient polygenes from different sources and improve field resistance considerably. When we now breed new late-blight resistant cultivars, we pay special attention to the selection of recombinant genotypes or TR hybrids. To evaluate them in the first clonal generation we use artificial inoculation of detached leaflets with subsequent long-term field evaluation. Using TR hybrids, we created parental lines, combining a high field resistance to *P. infestans* with high productivity and other valuable characteristics. In 2016 our collection of TR hybrids contained 75 lines. The frequency of suitable TR hybrid genotypes in the progeny depends on the crossing type, the level of parental resistance and the combining ability of parents with respect to productivity and other valuable characteristics. The analysis of 30 hybrid populations, evaluated in different periods, showed that the average frequency of TR hybrids is quite stable, with an average of 2.1-2.7 % (Table 2); however, this frequency varies considerably between individual populations.

Table 2. Characterization of two groups of hybrid populations regarding the frequency of transgressive recombinants (TR hybrids)

Evaluation period	Number of popelations studied	Number of hybrids studied	Frequency of TR hybrids (%)	Range of frequencies of TR hybrids in individual populations (%)
2003-2006	**11**	**1,904**	**2.7**	**0.7-7.5**
2011-2013	**23**	**2,450**	**2.1**	**1.0-6.4**

The highest TR hybrid frequency wax registered in progenies of parents with high and average late-blight resistance. When resistant and susceptible genotypes are

crossed, the percentage of TR hybrids sharply decreases; however, the use of susceptible parents is necessary, since such cultivars and lines represent mainly early-maturing genotypes. The introduction of polygenes for early maturation into the starting breeding material provides a possibility for breeding early cultivars with relatively high field resistance to *P. infestans.* For example, cv. Udacha is a natural TR hybrid obtained by the common breeding scheme and is selected from the Vilnya x Anoka population. The analysis of 50 selected TR hybrids with high field resistance (scores 7-8) showed that most of these hybrids (90.4%) were selected using middle-late cultivars. The frequency of TR hybrids obtained by crossing mid-maturing with middle-early parents was equal to 5.4%. In the case of crossing middle-early and early parental genotypes, only 3.6% of TR hybrids could be selected. Characteristics ot selected TR hybrids selected from different crossing types are shown in Table 3. Hybrids obtained by crossings between the mid-maturing cv. Lugovskoy and several middle-late cultivars (Zarevo, Nikulinskiy, Peterburgskiy) demonstrated high field resistance to *P. infestans.* The R x MR and R x S types of crossings usually caused a loss of 1-2 resistance scores, especially during the severe epidemic in 2015. Nevertheless, tuber resistance of all hybrids obtained from the early-maturing parents (Udacha, Utenok, Rossiyanka) was sufficiently high and many of these hybrids had enough time to produce a high yield.

Table 3 Characteristics of TR hybrids resistant to *P. infestans*

Origin and crossing type (concerning the resistance to *P. infestans*)	Resistance scores to *P. infestans**				Productivity (g/plant)
	Artificial inoculation		Field evaluation during the epidemic		
	Leaves	Tubers	2015	2016	
Nikulinskiy x Peterburgskiy (R x R)	7.5	9.0	8.0	8.0	960
Nikulinskiy x Peterburgskiy (R x R)	7.0	9.0	7.0	8.0	1100
1977-76 x Zarevo (R x R)	8.9	9.0	7.5	8.0	745
Nikulinskiy x Kalinka (R x MR)	7.7	9.0	7.0	8.0	717
Nikulinskiy x 88.16/20 (R x MR)	6.7	9.0	7.0	8.0	820
Udacha x 88.16/20 (R x MR)	5.5	9.0	5.0	8.0	1070
Udacha x 88.16/20 (R x MR)	5.0	8,5	3.0	7.5	1030
Udacha x Utenok (R x S)	6.5	7.5	7.0	8.0	780
Nikulinskiy x Ausonia (R x S)	5.0	9.0	6.0	8.0	1230
Udacha (early)	5.6	7.3	3.0	5.0	1430
Nevskiy (middle-early)	5.8	4.2	2.0	7.0	933
Lugovskoy (mid-maturing)	7.0	8.0	5.0	8.0	1270
Nikulinskiy (middle-late)	6.3	8.3	5.0	8.0	1180

***R – resistant, MR –moderately resistant, S – susceptible**

9 – resistant (without symptoms), 1 - susceptible (100% affected)

Since the frequency of recombinants with high field resistance and early maturity is quite low, we need about two to three generations to select genotypes combining these properties. We use many TR hybrids with high field resistance to *P. infestans* and other valuable characteristics its parental lines and, at the same time, evaluate them according to the breeding scheme. *Breeding of Potato Cyst Nematode Resistant Varieties* The most widespread pathotype of *Globodera rostochiensis* in Russia is Rol. In 1987 the first sources of resistance to this pathogen originated from Germany cultivate: Hydra (three new cultivars—Bezhitskiy, Zhukovskiy ranniy and Rossiyanka - originated from this cultivitr), Gelda (Lukyanovskiy and Zavorovskiy) and Kardia (Aspiya, Solnechniy). Recently we bred new nematode-resistant cultivars, based on our own cvs. Malinovka and Krepysh. To detect new sources for resistance to nematodes we analysed the collection of wild *Solanum species* and evaluated them at the Russian Institute of Helminthology. We detected only one new source, *S chacoense* 58d, which was already used for breeding PVY-resistant cultivars. Amphidiploids (*S. vernei x S. chacoense*, 2n=48) were repeatedly crossed with different cultivars. During the period 1998- 2005 we analysed segregation of nematode resistance in 18 populations obtained from crosses involving three-species hybrids ((vrn x chc) x tbr) and 10 backcross populations (vrn x chc) x tbr^2. The results confirmed that resistance is determined by a single dominant gene. Among the backcrosses we selected several resistant hybrids, such as

591m-29, 596m-46 and 59lm-279 (Yashina et al. 1987). Two resistant cultivars Bryanskiy delicates, originating from backcross 59lm-29, and Nakra, derived from backcross 596m-279 – were obtained. Using *S. chacoense* 58d, we bred an additional cultivar, Slava Bryanschiny, resistant to *G. rostochiensis* Ro1. Nowadays we use two parental lines, backcrosses 88.16/20 and 88.34/14, in our breeding programme to obtain potato cyst nematode resistant cultivars. These lines have high pollen fertility, high resistance to PVY and moderate resistance to *P. infestans,* colorado polato beetle and stress factors (heat and drought). Since 2008 we have used a special collection of 32 cultivars and hybrids with resistance to the Rol pathotype; 15 samples from this collection are original hybrids, combining Rol resistance with early-blight and late-blight resistance and also resistances to viruses. We use new potato cyst nematode-resist aut cultivars bred in Russia (Pushkinets, Nayada) and Belarus (Albatros, Atlant, Rosinka, etc) as starting material but also some foreign cultivars, such as Ausonia, Sante, Aroza and Maestro, for breeding. To increase the efficiency of laboratory testing for resistance to the Ro1 pathotype we have improved the assessment methods and the accuracy of the resistance assessment. Evaluations are performed in the basic stages of the breeding process (10). *Breeding of Cultivars with High Starch Content* The starch content in potato tubers determines the cooking and processing characteristics of a cultivar. In Russia high starch content is traditionally associated with good taste of potato tubers and their mealiness. The optimal starch content for table cultivars is considered to be about 18-20%; however, adverse weather conditions and a short growing season, typical for Central Russia, often decrease the value of this parameter by 2-3%.Our programme of breeding new cultivars with high starch content started by studying the inheritance of this property. During 1994-2006 we evaluated 39 populations, obtained by self-fertilization and crossing of different parental genotypes. We found that starch content in tubers is determined by a small number of additively acting genes. On the basis of the analysis of the frequency distribution of starch content classes in the segregating progenies, we determined two independent loci responsible for the manifestation of this property (5). We also registered a symmetrical distribution of frequencies, the presence of transgressions and a high correlation between average starch contents in the tubers of parental genotypes and in the progenies (the correlation coefficient for the populations studied varied from 0.85 to 0.95). The type of inheritance of starch contents and the small number of loci involved allow us to use several simple methods for the improvement of this characteristic. These methods include the use of parental lines with increased starch content and the selection of positive transgressions in the progeny. However, a negative correlation between high starch content and high yield complicated this breeding work. The analysis of 26 hybrid populations (1995-2003) showed that the correlation coefficient between these properties varied from weakly positive (0.394) to weakly negative (—0.248) values. Positive correlations were registered for populations with lower starch contents. When the average starch content for a population was 15-21%, there was virtually no correlation between these traits and progenies with higher starch contents showed a negative correlation, ranging from -0.49 to -0.72. These findings explain also the low frequency of hybrids combining high starch content and high yield. The evaluation of 30 hybrid populations, carried out in 2003, showed that ihe average frequency of genotypes with high yield (>1000 g/plant) and high starch content (>18%) was only 0.5%, but varied significantly depending on the population (from 0 to 8.7%). Therefore, a preliminary frequency analysis of desired genotypes in hybrid populations can be very useful for successful breeding. In the following period (2005-2010) we widely used cv. Zarevo for breeding, since this cultivar has high starch content (22-26%), field resistance to *P. infestans* and at the same time relatively large tubers. Most of the culiivars with high starch content are late-maturing; therefore, our aim is to breed early and mid-early cultivars with increased starch contents. Using radiation selection and mutagenesis, we have generated new starting materials for this purpose (Simakov et al. 1991). We also obtained the

first hybrids with valuable characteristics. The evaluation of these hybrids will allow us to identify the most effective breeding methods. *Breeding New Cultivars for the Potato Processing Industry*The breeding of potato cultivars for the potato processing industry is a relatively new breeding goal. The first studies were carried out in 1980-1983, when we assessed the starting material and analysed the inheritance of this property. The suitability of samples for processing was estimated by the colour of crisps using the nine-point scale. Our study was based on the theoretical analyses of Accatino et al. (1973), who detected two dominant genes controlling suitability of tubers for reconditioning. We also used information about breeding for quality described by Ross (1986). On the basis of the analysis of different progenies we found also that the suitability for processing is determined by two dominant genes, interacting in an epistatic manner (Yashina and Yurieva 1992). Later (2003-2004) we analysed 32 additional progenies. In most populations we detected suitable genotypes for reconditioning with a frequency between 4.0 and 32.1%. In five populations we found suitable genotypes for processing without any reconditioning with frequencies from 4.8 to 15.2%. Similar data were obtained in 2003 -2005 during the analysis of 12 hybrid populations. We also determined suitability for processing for different periods of storage. We selected 22 hybrids highly suitable for processing for the whole storage period. These hybrids have also other valuable characteristics and are used as starting material for this type of breeding.

Improvement of Breeding Methods

Successful breeding is determined not only by the genetic basis of breeding material, but also by the use of reliable methods for evaluation and selection of valuable genotypes. To study the influence of the selection background, we developed the program of parallel evaluation of identical hybrid populations in different soil and climatic zones of Russia (16). Our breeding centre formed three to four identical sets for each population studied and then sent them to different breeding institutions in the European part of Russia, to Siberia and to Fur East Russia. These institutions tested the populations according to a common breeding scheme. The trials showed that new cultivars are selected from different populations in different regions. Only four cases of common selections were registered. In this way the number of selected cultivars increased considerably (2, 17). During the last decade (1998-2017) our institute bred 41 new cultivars and another ten cultivars were established in collaboration with other breeders. The total number of new varieties suitable for different soil and climatic conditions is now 60. The results of our studies confirm that the use of various selection environments is more effective than selection in a single region. Breeding efficiency can be increased and financial expenditure for breeding new cultivars can be decreased. In recent years we have also used some new molecular and genetic methods, including PCR analysis for genotyping potato cultivars, investigation of the variability within meristematic lines, identification of mutations, detection of viruses and viroids, and investigation of the breeding material using DNA markers tor genes involved in resistance to different pathogens. We have also started a programme of transgenic potato cultivars. -

Conclusion

According to the results of the analysis of pedigrees of 10 varieties originating from the two forms of *S. chacoense*, a high efficiency of carrying out recurrent crossings by the type of accumulators is established, which allow introgression of the dominant immunity genes to the virus Y. All the hybrids selected in different populations are highly resistant to viral diseases, which confirms the presence of a gene of immunity to the virus Y, transferred from the wild species. In the offspring of the accumulating crosses, there is a positive selective shift in field resistance to late blight. But among the stable backcrosses, late-ripening forms predominate. The accumulation of polygenes is also observed in offspring obtained with the participation of mid-ripening and mid-late varieties. But the frequency of stable forms is much lower than with accumulating crosses. The use of early maturing varieties used for recurrent crosses is expedient to alternate through a generation with medium-and middle-late-late forms resistant to late blight. For the recombination

of field stability with an earlier maturation period, genetically distant backcrosses obtained from different sources will be crossed. To implement the breeding program for resistance to the pathogenotype Ro1 of the golden potato cyst-forming nematode, a collection of varieties that are resistant to this nematode pathotype is formed. The collection includes 32 forms of different genetic origin, of which 15 backcross hybrids combining resistance to nematode with resistance to viruses, late blight and alternaria, Also it includes Russian and foreign varieties. In selection for increased starch, it is effective to use parents with a high starch content in tubers and to select positive transgressions in the offspring, despite the negative relationship between starchiness and yield. A relatively new direction in our breeding programs is the creation of varieties suitable for processing on potato products. When studying a large group of hybrid populations, the timing of the assessment of the selection material for determining the suitability for processing at different storage periods was specified. Methods of selection of parental forms are also specified. Hybrids with high processing capacity have been identified throughout the storage period and do not need to be re-conditioned. The repeated use of identical hybrid populations for selection in different ecological and geographical conditions increases the efficiency of selection and significantly reduces the financial costs of breeding a variety of potatoes.

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