Ways to increase the adaptability of potato varieties in the North Caucasus

S V Likhnenko1, F T Zangieva1, T A Morgoev2 and B V Bekmurzov2

1 North Caucasian Research Institute of Mountain and Piedmont Agriculture – the Affiliate of Vladikavkaz Scientific Centre of the Russian Academy of Sciences, North Ossetia-Alania, Mikhailovskoe, 1 Williams st, Russian Federation
2 Vladikavkaz Scientific Center of the Russian Academy of Sciences, North Ossetia-Alania, Vladikavkaz, 22 Markus st, Russian Federation

E-mail: mirlen@mail.ru

Abstract. Increase of the adaptation of potato varieties is possible due to the selection of varieties with wide ecological plasticity, resistant to late blight, viral diseases, quarantine diseases, heat and drought, which can produce high yields under changing weather conditions. Creation of varieties combining such a set of characters is possible with backcrosses. For the selection of donors, it is necessary to use stability assessments for one or another characteristic when grown in different ecological zones. Identification of stable genotypes in the early stages of selection using biophysical and physiological and genetic rapid methods helps to reduce laboratory and field surveys of the selection process. As a result of many years of work, varieties and hybrids resistant to heat, drought, were created; productive hybrids resistant to late blight and quarantine objects were identified. In the PCR laboratory of the VSC, genes for resistance to viruses and to golden potato nematodes were identified; in two hybrids, genes for resistance to golden and pale potato nematodes were identified. On the basis of mathematical calculations, environmental plasticity, homeostatic, stress resistance, and breeding value of some breeding samples have been determined.

1. Introduction
The main potato planting in the North Caucasus region are concentrated in the foothill zone with a temperate continental climate, with sharp fluctuations in meteorological elements, both over the years and during the growing season. Every year, abiotic and biotic factors cause a decrease in the yield and quality of potato tubers in the region. For the first are characteristic; high temperature during the period of growth of tops and tuberization against the background of a low moisture content in the soil, its relative moisture in the future. For the second; increased density of insects - carriers of diseases, prolonged contact with them, the intensive development of primarily viral, viroid, fungal, bacterial diseases. For normal growth and development in this region, introduced plants must have a wide range of ontogenetic adaptability. The main task of breeding is to increase the overall adaptability of newly created varieties [1]. The work of breeders is aimed at creating early, mid-early and mid-ripening new varieties resistant to cancer, potato nematode, viral and fungal diseases, heat and drought. For conducting directed breeding for the cultivation of potato varieties with given parameters, the selection of initial forms for hybridization and the selection of hybrids characterized by a high level of phenotypic
manifestation of a large number of basic breeding characters are of great importance. Therefore, the basis for increasing adaptability is the selection of donors with genes for resistance to diseases and climatic stresses, the creation of varieties adapted to stress loads [2]. Of great importance in modern conditions is the use of techniques and methods that contribute to reducing the time for the cultivation of new varieties, and reducing costs when implementing the program, increasing the effectiveness of the breeding process. The use of molecular markers or marker-assisted selection in breeding can reduce the number and volume of laboratory field tests, thereby reducing the breeding process [3,4]

2. Methodology and conditions

The studies were conducted according to the selection scheme developed at SKNIIGPSH VSC RAS in accordance with the guidelines for potato breeding technology [5]. Selection of climate-stress-resistant breeding samples was carried out according to the SKNIIGPSH methodology “Assessment of breeding material for heat and drought tolerance” (2010). The main results were obtained in the nurseries of collection, preliminary, main and competitive tests on the experimental basis of SKNIIGPSH VSC RAS in the forest-steppe zone of North Ossetia-Alania in 2012-2019.

Genetic analysis of hybrid populations on economically valuable traits was carried out in the first tuberous reproduction on 100 genotypes. Phenological indicators were taken into account to assess the early maturity of hybrids, the identification of which was carried out on the basis of an improved indirect method according to the morphological type of the bush and the physiological state of the tops at the stage of single-stage and dynamic digging in competitive test nurseries.

Laboratory studies to determine the latent form of phytopathogens were carried out by enzyme immunoassay. For molecular screening of breeding valuable genotypes, DNA markers were used using equipment for polymerase chain reaction (PCR) [6]. The quality assessment of potatoes was carried out in accordance with state standards (GOST) 26832-86 "Fresh potatoes for processing into food". The shape, size and surface of the tubers, the depth of the eyes, the color of the peel and pulp were evaluated. The darkening of the pulp of raw and boiled tubers was determined. The biochemical parameters of potato tubers were determined. The starch and dry matter contents were determined by the gravimetric method.

Research results. Varieties of early, mid-early and mid-ripening ripeness groups are recommended for the North Caucasus region. The inheritance of the precocity trait is determined by the action of multiple non-allelic genes and depends on the number and degree of their interaction. Thus, successful selection of precocious forms combining a complex of economically valuable traits is possible with an appropriate selection of source material of interspecific origin for return crosses [7].

Early-ripening forms can be obtained in the offspring of parents belonging to different groups of maturation. The largest percentage of early-ripening (from 25 to 60%) hybrids can be obtained by crossing early, mid-early and mid-ripe forms (potatoes of Russia). To obtain early ripening, mid-ripening hybrids with complex resistance to the main pathogens, high productivity and high starch content in tubers, it is necessary to involve resistant varieties, interspecific hybrids and wild species in hybridization [3].

In the forest-steppe zone, 1,427 genotypes of 10 hybrid combinations were grown on the experimental field. For resistance to viral diseases, combinations Romano x 07.603 / 2, Romano x 07.603 / 5; Kuznechanka x Luck; 87.759-3 x Reserve; Innovator x Premier; Bars x Adretta, Roco x Romano. In the hybridization of the mid-season Roko variety with the mid-early Romano variety, we identified 15% of the early, 30% of the mid-early and 5% of the mid-ripening forms. In the combination of Bars x Adretta, 10% of early, 45% of mid-early and 10% of mid-season were selected. When assessing the correlation dependence between productivity and morphological characters (foliage, height, developmental power, number of stems, type of branching) of hybrids, it was found that the magnitude and direction depends on the ripening time. In the selection of medium early forms of the cultural type, selection is effective according to the height of the bush, the number of tubers and the developmental capacity. In the collection nursery 130 varieties of interspecific origin were studied. Varieties of Luck, Vega, Gioconda, Kibits, Queen Anna, El Mundo belong to an early ripe group.
Varieties are referred to mid-early; Gala, Leopard, Oceania. Varieties Grandma, Musinsky and the Blue Danube are part of the medium-late group. According to a visual assessment, 43 varieties were not affected by viral diseases (Bars, Predgorny, Luck, Gala, Innovator, Kuznechanka, Gioconda, Niksa, Passwords, Queen Anna). The remaining samples are affected by wrinkled mosaic, speckled mosaic and Gothic from 0.6 to 14%. However, in 14 visually healthy varieties, threadlike plants formed. The appearance of filaments is caused by the latent accumulation of viruses.

In the North Caucasus, the death of potato plants in wet years can occur in May-June from late blight. The most cost-effective and environmentally friendly method of controlling the pathogen Ph. Infestans is the creation and cultivation of resistant varieties. Selection for late blight resistance is difficult to carry out in the North Caucasus because of the high diversity of races and strains. Currently there are many new varieties resistant to late blight. Many of them carry dominant R genes. Monitoring of field resistance to late blight by additively acting polygenes shows that for use in breeding work, selection and selection of parental pairs by phenotype are highly effective. The higher the stability of the parental forms, the higher the stability of the offspring and the more valuable the original form [7]. Field resistance allows one to successfully select for late blight resistance by accumulating crosses and selecting transgressive genotypes that exceed parental forms in terms of degree of resistance [7]. Hybrids with economically valuable traits for late blight resistance were studied in the nurseries of preliminary, main, and competitive trials. Resistant varieties to this pathogen have been identified; Lugovskoy, Anda, Kuznechanka, hybrids 10.666 / 40, 10.666 / 55. Qualitative indicators of tubers were determined; the content of starch, dry matter, darkening of raw and boiled pulp.

From 2017 to 2019, 65 varieties of cancer resistant to the Dahlem pathotype were studied in a collection nursery. Varieties resistant to the golden potato nematode are: Vega, Gala, Bars, Gioconda, Kibits, Queen Anna, Oceania, El Mundo [8].

A preliminary test of the first year for resistance to quarantine pathogens in the All-Russian station for testing potatoes for resistance to cancer and potato nematode hybrids 07.603 / 2, 07.603 / 5, 07.607 / 1, 06.598 / 2, 04.579 / 5, 03.560 / 4 were passed. As a result, the listed hybrids were resistant to S. endobioticum, and G. rostochiensis, in the future, these and other selected samples will undergo research in this direction. Hybrid 04.573 / 1 as a result of preliminary and state field tests at the All-Russian Cancer and Potato Nematode Potato Testing Point was characterized as resistant to the Dahlem cancer type and Golden potato nematode (Ro 1 type).

In 2019, in the nurseries of the first and second year competitive tests, screening of 45 hybrids using marker assisted selection methods allowed the donors of R genes of extreme resistance to the Y potato virus to be identified: a) with the presence of the Ryadg gene, genotype 4666/14; b) with the presence of the Ryche gene – 4684/38, 07.640 / 7; c) with the presence of the Rysto gene – Volzhann samples, 4666/12, 10.666 / 9, 10.666 / 38, 10.666 / 40, 10.666 / 45, 10.666 / 173, 10.666 / 99, 10.666 / 109, 10.666 / 225, 10.666 / 35, 10.667 / 21, 10.667 / 40, 100 / II, 09.633 / 1.

Hybrid sample 07.640 / 1 showed immunity to the X virus with the presence of the Rx1 gene. Genotypes 10.666 / 70, 10.667 / 130 with extreme resistance to potato viruses X and Y with a combination of the Rysto and Rx1 genes were detected.

Breeding forms with resistance genes for the potato nematode, G. rostochiensis were revealed: a) with the presence of the H1 gene - 4738/17, 4738/24, 10.666 / 19, 10.666 / 38, 10.666 / 10, cultivar Koroleva Anna, cultivar Impala; b) with the presence of the Gro1-4 gene, samples 10.666 / 40, 10.666 / 25, 10.666 / 35, 40 / II, 10.667 / 40; c) with a combination of the H1 and Gro1-4 genes of resistance to the golden potato nematode - samples 10.666 / 10, 10.667 / 21, 10.667 / 40, 10.667 / 45, d) with the presence of the Gpa2 gene of resistance to the pale potato nematode - samples 10.667 / 70, d) with a combination of the H1 and Gpa2 genes of resistance to both types of potato nematode - samples 10.667 / 130, 107.640 / 1. All resistant forms will be used as donors in saturating hybrid crosses.

Over the years, abiotic stresses have also affected plant development and tuber accumulation. Resistance to heat and drought is known to be controlled by additive genes [9]. In this regard, a search was made for new fever, drought-resistant hybrids and varieties. Varieties and hybrids for stability were evaluated by the express method based on measuring the electrical resistance of leaf tissues and
observations in the field during hot and dry periods. Evaluation was given according to our developed methodology. Resistant to elevated temperatures hybrids 07.600 / 1, 07.600 / 4, 07.549 / 1. Using mathematical methods, stress resistance, plasticity, homeostaticity and breeding value of hybrids and varieties of breeding breeding are determined.

| Variety, hybrid | Tuber harvest, t / ha | Y1 | Y2 | (Y1 + Y2)/2 | Hom | Sc |
|----------------|----------------------|-----|-----|-------------|-----|-----|
| 03.560/4       | 23.2                 | 17.0 | 28.5 | -11.5       | 22.7 | 59.8 | 13.8 |
| 03.560/7       | 15.3                 | 7.9  | 23.4 | -16.4       | 16.1 | 34.1 | 4.9  |
| Sorokinsky     | 15.3                 | 8.8  | 24.0 | -15.2       | 16.4 | 37.1 | 5.6  |
| 04.579/5       | 22.0                 | 17.1 | 24.5 | -7.4        | 20.8 | 142.0 | 15.3 |
| 06.598/3       | 10.3                 | 5.7  | 13.9 | -8.2        | 9.8  | 106.9 | 4.2  |
| 06.598/12      | 11.0                 | 13.5 | 17.1 | -6.1        | 18.9 | 116.8 | 8.6  |
| Scherbininsky  | 18.6                 | 15.3 | 22.5 | -7.2        | 18.9 | 116.8 | 12.6 |
| 07.605/10      | 18.9                 | 17.2 | 20.2 | -3.0        | 18.7 | 279.0 | 16.1 |
| 07.607/1       | 18.3                 | 14.1 | 21.9 | -7.8        | 18.0 | 104.6 | 11.7 |
| Bars           | 23.1                 | 19.0 | 28.3 | -9.3        | 23.7 | 317.0 | 15.5 |
| Piedmont       | 18.5                 | 17.5 | 20.0 | -2.5        | 18.7 | 90.1  | 15.9 |
| Tersky 1       | 15.1                 | 15.2 | 15.8 | -0.6        | 15.5 | 201.7 | 14.5 |

Table 1. Assessment of the adaptability of varieties and hybrids of potatoes 2012-2018.

Studied breeding objects during the years of testing were exposed to both abiotic and biotic stresses. In the wet years, there was an intense infection with late blight and early death of plants.

Stress resistance, plasticity, homeostaticity, and breeding value were calculated on the basis of observations obtained. U2 - minimum tuber yield, U1 - maximum, and the smaller the difference Umin-Umax, the more stable the variety. The average yield of the variety in contrasting conditions (U1 + U2) / 2 characterizes its compensatory ability. The higher this indicator, the higher the degree of correspondence between the genotype of the variety and various environmental conditions, its plasticity, and adaptability to different conditions [10]. Homeostaticity and breeding value were calculated according to the method of V.V. Khangildin. [11]. The indicator of homeostaticity shows the ability to give a stable crop in different conditions. Predgorny variety, hybrids 03.560/4, 06.598/3 showed high resistance to stress. Breeding samples Piedmont, Scherbininsky, hybrids 07.607/1, 07.605/10, 04.579/5, showed a higher adaptability to changing environmental conditions. Variety Bars, hybrid 07.605/10 stand out for their high homeostaticity and breeding value, the data are presented in table 1.

3. Conclusion
As a result of our studies in the field and laboratory conditions, resistant genotypes for viral diseases and quarantine pests, heat and drought were identified. Resistant varieties to cancer - Tersky, Predgorny - have been created. The variety Bars and hybrid 04.573/1 are resistant to the golden potato nematode. The stress resistance, adaptability, homeostaticity and breeding value of hybrids and varieties are evaluated. Based on the results, the isolated resistant genotypes will be used in further hybridization.

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