Efficiency of the breeding use of the genus *Prunus* L. biodiversity

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Abstract. Preservation and search of the source material of the *Prunus* L. gene pool for breeding, especially in contrasting weather conditions, it becomes particularly relevant. Breeding collection of representatives of the genus *Prunus* L. NCFSCHVW: sweet cherry (*Prunus avium* L.), common cherry (*Prunus cerasus* L.), plum (*Prunus domestica* L.), has more than 500 samples and is the basis for improving the genotypes of stone fruit plants. The purpose of the research is to evaluate the breeding potential of stone crops and to identify unique variety forms for new varieties creation. The paper presents donors and sources of important traits: early fruitfulness, winter hardiness, drought resistance, resistance to *Coccomyces hiemalis* Higg., *Monilia cinerea*, large fruitfulness and productivity, and substantiates their importance in ensuring the further breeding process and updating the gene pool of stone crops. The best varieties, primarily of domestic breeding, with specific characteristics for integration into new breeding programs are selected: sweet cherry – Madonna, Kavkazskaya Uluchshennaya, Volshebnitsa, Cherniye Glaza, Alaya and Mak; cherry – Krasnodarskaya Sladkaya, Kazachka, Kirina Kubanochka, Alexa; plum – Prikubanskaya, Krasnodarskaya, Milena, Podruga, Charodeyka, Krasotka, Gertsog.

1 Introduction

The problem of conservation and rational use of genetic resources is of global importance. This is evidenced by the programs of international organizations (FAO, UNDP, ECCDS, IPGRI, EUCARPIA, ECPGR, AEGIS, EURISCO, etc.), co-implemented by Russia, having unique collections of agricultural plants [1,2]. Even N.I. Vavilov identified one of the main tasks for solving the problem of food security of mankind – the maintenance and study of cultivated plants collections, the identification of genetic sources and the creation of adaptive varieties on their basis [3]. According to the Convention on Biodiversity, each species, ecotype, and local variety is a unique transition to an ecological-biosphere strategy [1,4]. There is no doubt that the study of the *Prunus* L. gene pool under stressful conditions and an extremely changing climate is of particular relevance [5]. In this connection, the "North Caucasus Federal Scientific Center of Horticulture and Viticulture" preserves and annually replenishes the collection of fruit stone plants, which includes more

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than 500 varieties of sweet cherry (*Prunus avium* L.), common cherry (*Prunus cerasus* L.), plum (*Prunus domestica* L.) of various ecological and geographical origin (Canada, USA, Italy, France, England, Germany, America, Czech Republic, Belarus, Moldova, Ukraine, etc.). The gene pool is stored in the field, from three to five or more samples of each genotype. Based on the relevance of assessing the genetic variability of collections, the purpose of the study is to assess the breeding potential of stone crops and identify unique variety forms for new varieties creation.

2 Materials and Method

Evaluation of the effectiveness of stone crop collections use allowed to conclude that hybridization was carried out according to breeding programs developed for each crop, which allowed to identify donors, sources and create genotypes with improved traits [3,6]. Thus, breeding for large-fruitness, fruit quality, adaptability and productivity, with the involvement of the best donors and sources of valuable biological traits remains the main directions for plum [4,7].

3 Results and Discussion

The evaluation of varieties as parental forms in plum breeding showed that more often varieties of Izyum Kubansky, Persikovaya, Vengerka Italyanskaya, Vengerka Azhanskaya, Renklod Zeleny, Veliky Gertsog, Stanley, Kabardinskaya Rannyaya, etc. were used in the crosses. And on their basis, Russian varieties were created: Krasnodarskaya (Vengerka Azhanskaya × Veliky Gertsog), Prikubanskaya (Vengerka Azhanskaya × Renklod Zeleny), Milena (Izyum Kubansky × Vengerka Italyanskaya), Krasotka (Kabardinskaya Rannyaya × Stanley).

To increase fruit weight, large-fruited varieties of plum Veliky Gertsog, Persikovaya, Kabardinskaya Rannyaya, Stanley were taken as parental forms in the breeding, which made it possible to create genotypes with relatively large fruits, the weight of which varied from 38.3 to 50.5 g. These are the Gertsog (Metelka × pollen mix of Veliky Gertsog+Persikovaya), Charodeyka (Anna Shpet × pollen mix of Stanley+Kabardinskaya Rannyaya), Milena (Izyum Kubansky × Vengerka Italyanskaya), Podruga (Vengerka Azhanskaya × Veliky Gertsog), Krasotka (Kabardinskaya Rannyaya × Stanley) varieties. The results obtained allowed to identify inheritance patterns of the large-fruited trait by plum progeny, indicating that when crossing both parental forms with large-sized fruits, there is a split with a predominance of hybrid seedlings with an average fruit weight of 39.5%, the share of large-fruited seedlings was 31.2%, seedlings with small fruits - 29.3%. It was found that heritability coefficient of large fruit size in plum varieties is high and is 0.55, the coefficient of variation is 39.2% [1,4]. The revealed inheritance patterns of taste qualities by plum progeny allow to state that most of the new genotypes of plum had fruits with taste qualities lower than those of the original parental forms. According to the data obtained, only about 36.0 % of plum hybrids inherit the high taste qualities of the parental cultivars. More than 50% of hybrid seedlings are characterized by low fruit quality indicators. Thus, domestic varieties of plum Milena, Gertsog, Charodeyka, Podruga are characterized by fairly high taste qualities of the fruit inherited from the parental forms of Izyum Kubansky, Veliky Gertsog, Anna Shpet, Kabardinskaya Rannyaya and Stanley (Table 1).

From the above, it can be summarized that the use of a limited number of varieties in directed crosses greatly narrows the genetic diversity, in particular of plum. With this in mind, the collection is annually replenished with varieties of various origins, including

native, wild samples, which makes it possible to replenish the invaluable reserve of useful genes and widely involve them in hybridization. The study of the breeding potential of plum varieties collection allowed to identify donors and sources of significant traits for introgression in the new generation varieties presented in Table 1.

Table 1. Source material for priority breeding programs for plum (*Prunus domestica* L.), (city of Krasnodar, NCFSCHVW General Collection)

Valuable traits	Donors, sources
Large-fruitness	Crimson Glo, Dark Sunlight, August Delight, Blue Moon, Big Stanley, Stanley, Kabardinskaya Rannyaya, Chernosliv Adygeysky, Milena, Charodeyka, Gertsog
Taste and marketability of fruits	Big Stanley, Dark Sunlight Stanley, Kabardinskaya Rannyaya, Chernosliv Adygeysky, Nectar, Milena, Krasotka, Gertsog
Drought and heat resistance	Big Stanley, Stanley, Balkarskaya, Asker, Turchanka, Chachakskaya Pozdnyaya, Chachakskaya Uluchshennaya, Gertsog, Charodeyka
Yield	Crimson Glo, Blue Moon, Dark Sunlight Stanley, Kabardinskaya Rannyaya, Chernosliv Adygeysky, Preedgornaya, Balkarskaya, Gertsog, Charodeyka, Prikubanskaya

The priority areas in cherry breeding are large-fruitness, taste qualities and resistance to major diseases [8]. Evaluation of collection varieties use showed that in cherry breeding, a limited number of parental forms were also used. These are mainly varieties of Kistevaya, Vladimirskaya, Chernokorka, Nord Star, Molodezhnaya, Igrushka, Vstrecha, etc. Nevertheless, it should be noted that along with hybridization, the method of induced mutagenesis was often used in cherry breeding, on the basis of which domestic varieties Kubanochka (hemomutant of the Kistevaya variety (Vladimirskaya x ground cherry), Alexa (mutagen of the Kirina variety (Vladimirskaya sv. op. x Ramon Oliva) were obtained [4]. It is known that as a result of induced mutagenesis, hybrids with a late maturation period, with small fruits and low taste qualities are more often distinguished. Nevertheless, it should be noted that the local varieties Alexa and Kubanochka, obtained by this method, belong to the group of medium-term maturation, have large fruits weighing 5-7 g and are characterized by high taste qualities, i.e. "surpassed" the original forms in a number of indicators. The use of interspecific hybridization of cherries allowed to increase the resistance to abiotic factors. Thus, the inclusion of steppe cherry (*P. fruticosa*) in the F₂ generation in the crossing caused increased frost resistance (up to -28°C) of the Kubanochka variety. Intervariety crosses involving the varieties Nord Star (Canada), Vladimirskaya (Russia), Chernokorka (Ukraine) of various ecological and geographical origin also allowed to obtain high-winter-hardy varieties Kazachka (Chernokorka x sweet cherry pollen mix), Nostra (a clone of the Nord Star variety). To improve the taste of new cherry varieties, hybridization included dukes that were superior in fruit quality to varieties of typical cherry, as well as sweet cherry varieties. According to these schemes, the varieties of Kazachka and Alexa were obtained, combining in their genotype the characteristics of dukes and the best cherry varieties. They are characterized by a high content of dry matter at the level of 16.8 %, sugars - 7.9 % and a low content of various acids, in the range of 1.5-1.7 %.

The evaluation of the common cherry genetic collection also made it possible to identify the best source material for the implementation of modern breeding programs (Table 2).

Table 2. Source material for priority breeding programs of common cherry (*Prunus cerasus* L.), (city of Krasnodar, NCFSCHVW General Collection)

Trait	Donors and sources	Domestic varieties
Winter hardiness	Shokoladnitsa, Kazachka, Shokoladnitsa, Orlitsa, Turgenevka, Nefris, Konkurentka, Prevoskhodnaya Kolesnikovoy	Chocolate girl, Eagle, Turgenevka, Competitor, Nostra, Prevoskhodnaya Kolesnikovoy, Alexa, Kubanochka, Kazachka
Drought resistance	Timati, Duke Khodosa, Vstrecha, Duke Ivanovna	Kirina, Kazachka, Feya
Resistance to coccomycosis	Novella, Molodezhnaya, Dombaziya, Feya, Elegiya, Juicy Fruit, Vstrecha, Timati, Orotak, Duke Ivanovna	Novella, Molodezhnaya, Feya, Alexa, Kubanochka
Resistance to moniliosis	Novella, Shalunya, Igrushka, Molodezhnaya, Turgenevka, Juicy Fruit	Kirina, Alexa, Kubanochka, Novella, Molodezhnaya
Early maturity	Prizvaniye, Igrushka, Nefris, Fanal, Duke Ivanovna	Krasnodarskaya Sladkaya, Kazachka
Low growth	Krishana, Malyska, Molodezhnaya, Orlitsa, Turgenevka, Tamaris, Feya	Kazachka, Krasnodarskaya Sladkaya, Molodezhnaya
Yield	Duke Ivanovna, Molodezhnaya, Nefris, Novella, Shalunya, Shokoladnitsa, Dombaziya, Orotak, Igrushka, Duke Hodosa, Prizvaniye	Kazachka, Kirina, Krasnodarskaya Sladkaya
High fruit quality	Chudo-vishnya, Krupnoplodnaya, Duke Hodosa, Prizvaniye, Dombaziya, Vstrecha	Krasnodarskaya Sladkaya, Kazachka

Analysis of the world's main cherry breeding programs has shown that they are based on five to ten main varieties, which also leads to a narrowing of the genetic base of cherry breeding [9, 10]. This trend confirms the need to expand genetic diversity by adding new samples to the collection. The NCFSCHVW genetic collection of sweet cherry (*Prunus avium* L.) is mainly represented by varieties of domestic and Western European breeding. The modern cherry breeding program contains several priority areas: breeding to increase the fruit weight to world standards, reducing the strength of the tree growth, self-fruitfulness, adaptability, etc. The main method of sweet cherry breeding remains inter-variety hybridization within this species, interspecific hybridization between *P. vulgaris* and *P. avium*, mainly aimed at improving the quality of fruits in common cherry varieties. The spur type of fruiting is not peculiar to sweet cherry, so one of the solutions to the problem of reducing the strength of tree growth is the use of mutagenesis, by the effect of gamma rays on the vegetative buds of the plant. This method was used to obtain the improved Kavkazskaya Uluchshennaya variety (a mutant of the Kavkazskaya variety), with a restrained growth force and a compact crown. Work is also being successfully carried out in the United States, where the low-growing variety Lambert Spur (mutant of Lambert) has been isolated. Mutant varieties should be further included in the breeding to reduce the tree size (Table 3). The creation of self-fertile sweet cherry varieties is an opportunity to obtain a stable harvest even in years when the conditions for pollination may be unfavorable. It is known that the first commercial self-fertile variety was Stella (S_3S_4), obtained at the Research Station of the Canadian Ministry of Agriculture in Summerland [11]. Modern commercial self-produced varieties Lapins, Skeena and Sweet Hart are derived from the Stella variety. This group of varieties should be included in saturating crosses with local varieties, as well as combinations within the group should be used, in this case, there is a high probability of obtaining self-fertile varieties for growing in specific conditions.

Abnormally low winter temperatures can reduce the yield of sweet cherries, although during the period of deep rest, the sweet cherry can withstand negative temperatures in the range of -28.0°C ... -30.0°C [5], so the "winter hardiness" trait is important for sweet cherry, since it determines the area of its possible cultivation. According to the results obtained,

combinations of crossing with the inclusion of Melitopolskaya Chernaya and Frantsuzskaya Chernaya varieties were effective. In combination with these varieties, a greater number of winter-hardy seedlings were selected and the best domestic varieties were selected: Alaya, Volshebznitsa, Dar Izobiliya and Mak. Good results were obtained when using the Krupnoplodnaya variety as the female form, on the basis of which the Kontrastnaya and Madonna varieties with a high frost resistance potential were obtained.

The program for improving the quality of sweet cherry fruits includes several main parameters: large size, hardness, sweetness, good organoleptic indicators, which together determines high taste qualities. When improving this indicator, good results were obtained due to free pollination of local varieties Sashenka and Alaya. Good results were obtained when the Anadolskaya cherry was used as a father variety in crossing with the Napoleon Belaya sweet cherry, as a result of this combination, the Barkhatnaya and Kavkazskaya varieties with high fruit quality were obtained.

Selection of large-fruited varieties is one of the subprograms for improving the marketability and quality of sweet cherry fruits [12]. Large fruits make a major contribution to consumers' perception of high-quality products, including sweet cherry. Using local and Ukrainian varieties of Alaya, Krupnoplodnaya, Melitopolskaya Chernaya in hybridization, a series of varieties was created – Cherniye Glaza, Sashenka, Madonna, which differ in large, marketable fruits weighing 8.0-10.0 g., which allowed to enrich the group of early and medium-early varieties with large-fruited varieties, in which they were particularly lacking.

Table 3. The main directions in sweet cherry breeding in the southern region, donors and sources of valuable biological traits (city of Krasnodar, NCF SCHVW General Collection)

Trait	Donors, sources of breeding traits	Country	New varieties with selected traits	
Low growth	Kavkazskaya	Russia	Kavkazskaya Uluchshennaya (mutant of the Kavkazskaya variety)	Russia NCF SCHVW
	Lambert	USA	Lambert Spur (mutant of Lambert)	USA
Self-fertility	Stella (S ₃ S ₄)	Canada	Lapins (Stella x Van)	Canada
		Canada	Skeena (Bing x Van x Stella)	Canada
		Canada	Sweet Hart (Van x Stella)	Canada
Winter hardiness	Frantsuzskaya Chernaya	Western Europe	Volshebznitsa (Drogana Zheltaya x Fr. Chernaya)	Russia NCF SCHVW
	Melitopolskaya Chernaya	Ukraine	Alaya (Melitopolskaya Chernaya sv. op.)	Russia NCF SCHVW
		Ukraine	Dar izobiliya (Mel. Chernaya x Fr. Chernaya)	Russia NCF SCHVW
		Ukraine	Mak (Mel. Chernaya x Fr. Chernaya)	Russia NCF SCHVW
	Krupnoplodnaya	Ukraine	Kontrastnaya (clone of Krupnoplodnaya)	Russia NCF SCHVW
		Ukraine	Madonna (Krupnoplodnaya sv. op.)	Russia NCF SCHVW
Fruit quality	Sashenka	Russia	Podarok Leta (Sashenka sv. op.)	Russia NCF SCHVW
	Alaya	Russia	Cherniye Glaza (Alaya sv. op.)	Russia
	Napoleon Belaya	Russia	Kavkazskaya (Napoleon Belaya x Anadolskaya cherry)	Russia NCF SCHVW
		Russia	Barkhatnaya (Napoleon Belaya x Anadolskaya cherry)	Russia NCF SCHVW
Large-fruitness	Alaya	Russia	Cherniye Glaza (Alaya sv. op.)	Russia NCF SCHVW
	Melitopolskaya Chernaya	Ukraine	Sashenka (Kavkazskaya x Melitopolskaya Chernaya)	Russia NCF SCHVW
	Krupnoplodnaya	Ukraine	Madonna (Krupnoplodnaya sv. op.)	Russia NCF SCHVW

4 Conclusions

Thus, the study of genetic collections contributes to the successful renewal of the assortment of fruit stone crops on the basis of the revealed inheritance patterns and selected

varieties of valuable traits donors and sources. Indicators of the effective use of genetic collections are the created domestic varieties that combine a set of significant features and allow to speed up the breeding process. To date, more than 40 varieties of stone fruit crops have been created in the NCFSCHVW, including sweet cherry: Alaya, Barkhatnaya, Volshebznitsa, Dar Izobiliya, Kavkazskaya, Kavkazskaya Uluchshennaya, Podarok Leta, Madonna, Mak, Sashenka, Cherniye Glaza; cherry – Krasnodarskaya Sladkaya, Kazachka, Kirina, Kubanochka, Alexa; plum – Podruga, Charodeyka, Krasotka, Gertsog, etc., many of which are included in the Register of breeding achievements of the Russian Federation, of interest for modern breeding and cultivation in the south of Russia.

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