

Using the genetic diversity of the *Malus* genus to solve the priority areas of breeding

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Annotation. The breeding use of the most valuable species and interspecies forms of fruit plants remains currently the most important biological resource for creating the varieties with increased adaptability to the complex of abio- and biotic stressors of the environment, improved biochemical composition of fruits and with other important features for breeding. The results of a long-term study (2005-2019) of interspecific hybrid forms of apple-tree-representatives of the *Malus* genus, growing in the North Caucasus Region of Russia are presented. The aim of the study is to identify the most rapid and productive interspecific hybrid forms of apple-tree with polygenic and oligogenic types of scab resistance (*Venturia inaequalis* (Cook) G. Winter). Modern breeding programs and methods were used. We have identified the early-fruiting interspecies apple forms created with the participation of the summer Melba variety, the species of *M. purpurea*. It is allocated the elite and selected apple forms resistant to scab with a high average yield (29.03-40.03 t/ha), high indicators of total yield (377.27-520.33 t/ha) from hybrid families with the participation of species: *M. atrosanguinea* 804/240-57, *M. floribunda* 821, *M. purpurea* and the large-fruited form No. 62 (created with the participation of Golden Delicious 4x, Wolf River, *M. atrosanguinea* 804/240-57) with fruits of 202.3 g an average weight.

1 Introduction

The development of the main ideas about the widespread using in breeding the methods of hybridization of apple geographically distant forms and interspecies hybridization, proposed for variety's improvement of fruit crops by I.V. Michurin – an outstanding breeder-innovator, is still relevant and in demand by the world scientists at present [1-4, 6]. In the breeding process of the most important agricultural fruit plants, many scientific teams are using actively the whole available potential of the crop genetic diversity to solve the priority breeding tasks [1-3, 5, 6]. There are great number of examples of positive solutions

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for some breeding problems by using the valuable species and interspecies forms to create the improved genotypes; one of the most widely known examples is the creation of apple varieties with scab resistance (the pathogen is the fungus *Venturia inaequalis* (Cook) G. Winter) based on the *Rvi6* gene (previously *Vf* under the old classification) from *Malus floribunda* 821 [7, 8]. It is known that the use of a limited number of initial parent forms in breeding significantly reduces the genetic base of created and cultivated apple varieties, which makes it difficult to obtain the major success in the field of signs and phenotypes [1]. Often, wild apple species and forms show a greater degree of variation in the biochemical composition of fruits than cultivated varieties, and so being the valuable origin of genetic variability within the culture [9-12]. It is promising a direction, received the increasing development in recent years, the creation of apple varieties with red fruit pulp of different intensity, with improved taste and a longer storage period [1, 6]. Reducing the juvenile phase of a fruit plant is certainly an important research of apple breeding, and encouraging results have been obtained now with the use of wild species and interspecies forms [13, 14]. The active breeding use of the most valuable species and interspecies forms of fruit plants remains the most important biological resource at present for creating the varieties with increased indicators of adaptability and resistance to abiotic stressors (spring slight frosts, frosts, droughts, insufficient or excessive moisture supply, unstable moisture regime, especially during the growing season), and with resistance and immunity to the main and the new fungal pathogens that have recently become more active and aggressive towards the plant, with productivity, improved indicators of quality and characteristics of the biochemical fruit composition; and with increasing environmental stability of new varieties and promising hybrids based on the widespread use of the gene pool of local varieties, as well as valuable wild forms and species [3, 15-18]. Due to the fact that in the world one of the main methods in the breeding of fruit plants – remote hybridization is being used more and more actively, it is promising to study the collection of promising interspecies apple forms as origin of significant characteristics. The purpose of the study is to identify the most fast fruiting and productive interspecific hybrid forms of apple-tree with polygenic and oligogenic types of scab resistance.

2 Objects and methods of research

The research was carried out in FSBSI NCFSCHVW (ZAO Experimental Production Farming "Tsentralnoye"), in the apple plantations of 2004. planting; rootstock M9; planting scheme 5×1.5 m. the Objects of research are the apple genotypes of different ploidy and genetic origin, the elite and selected apple forms of complex interspecies origin from 3 hybrid families: Melba × (*M. floribunda* 821 × Renet Simirenko): №№ 82, 98, 99, 100; Golden Delicious tetraploid × OR18T13 [Wolf River × (Wolf River × *M. atropurpurea* 804/240-57)]: №№ 61, 62, 65, 68, 70; Arcade Zimniy × (Renet Simirenko × *M. purpurea*): №№ 101, 102, 103, 105. As a control, the domestic scab-immune apple variety of Margot was taken, which is included in the State Register of breeding achievements approved for use in the North Caucasus Region. The research was carried out with the financial support of the Kuban science Foundation in the framework of the scientific project №IFR-20.1/92. Research was carried out according to generally accepted breeding programs and methods: "Program of the North Caucasus center for selection of fruit, berry, flower and ornamental crops and grapes for the period up to 2030"; "Modern methodological aspects of the organization of the breeding process in horticulture and viticulture"; as well as generally accepted: "Program and method of variety study of fruit, berry and nut crops".

3 Research Results

The genetic apple-tree collection of FSBSI NCF SCHVW currently contains 438 samples of various ecological-geographical and genetic origin and different ploidy. The collection includes the varieties, species, clones, forms, polyploids and complex interspecies hybrids of apple-tree. A significant part of the collection consists the varieties, elite and selected apple forms with oligogenic, digenic and polygenic types of scab resistance. It is considered that polygenic resistance to scab can provide the apple orchards with longer-term stability than the main resistance genes, so it is promising to create the joint plantings of varieties immune to this pathogen with varieties resistant on a polygenic basis [19]. Despite the fact that in modern breeding research on apple-tree, the main priority is given to a combination of resistance signs to fungal pathogens whis high commercial indicators of fruit quality, the high productivity remains the most important sign for new varieties and hybrids.

The evaluation of long-term data on the main components of productivity – fast fruiting; rate of growth, yield growth rate; average, maximum and total yield over fifteen-year period of the study (2005-2019), allowed us to identify the most fast fruiting and productive interspecies apple hybrid forms with polygenic and oligogenic types of scab resistance, which have a higher productivity potential in the Southern region of Russia (Table 1).

According to long-term years of research identified the most early breeding interspecies apple forms: №№ 98, 99, 101, 102, 103, 105, most of which are received in hybrid families involving enough early fruiting *M. purpurea*, and summer variety of Melba. Among them, the most fast-fruiting form № 102, was selected in the family Arkad Zimniy × (Renet Simirenko × *M. purpurea*), which begins fruiting with 1-2 years after planting in the garden.

Table 1. Estimation of fruit rate, yield capacity and fruit weight of interspecies hybrid forms of apple-tree, 2005-2019

Interspecies apple hybrid forms	Year of fruiting start	Average fruit weight, g	Yield (2007-2019)					
			average		maximum		total	
			kg/ tree	t/he	kg/ tree	t/he	kg/ tree	t/he
61	3	196,6	16,83	24,43	29,33	39,10	219,00	291,90
62	2	202,3	21,77	29,03	40,67	54,20	283,00	377,27
65	3	186,5	18,57	24,77	35,67	47,53	241,67	322,13
68	2-3	193,7	15,07	20,07	33,67	44,90	196,00	261,27
70	3	144,2	13,53	18,07	27,33	36,43	176,00	234,57
82	3	48,5	11,83	15,80	33,33	44,47	154,00	205,27
98	2	39,3	4,57	6,07	9,33	12,43	59,67	79,50
99	2	98,9	25,13	33,50	38,33	51,10	327,00	435,90
100	3	59,3	15,07	19,97	32,33	43,10	195,33	259,50
101	2	51,7	10,63	14,20	30,00	40,00	138,33	184,40
102	1-2	146,1	23,37	31,17	36,00	48,03	304,00	405,23
103	2	134,5	30,00	40,03	36,67	48,87	390,33	520,33
105	2	122,8	15,07	20,07	24,67	32,90	195,67	260,83
Margot (control)	2-3	204,4	21,64	28,85	35,00	46,65	281,33	375,01
LSD _{0.5}		4,53	1,49	1,73	1,62	1,87	5,39	6,22

The evaluating of the productivity potential of interspecies elite and selected apple forms allowed us to identify scab resistant genotypes №№ 62, 99, 102, 103 with a high average yield capacity (from 29.03 t/he to 40.03 t/he) and with high indicators of total yield capacity (from 377.27 t/he to 520.33 t/he), promising for inclusion in the characteristic collections of apple-tree and further in-depth study using the modern molecular genetic and cytological research methods.

The maximum yield capacity over the years under study had a fairly high value for most of the studied apple forms (from 32.90 up to 54.20 t/he). As an exception, we can distinguish a small-fruited form № 98 with low indicators of average, maximum and total yield, that can be explained by the lowest value of average fruit weight (39.3 g) in this form among all genotypes studied, as well as the periodical fruiting (possibly it inherited from the mother's Melba original form, which differs periodical fruiting to a fairly strong degree).

Among the interspecies apple forms studied by us, the most small-fruited ones are in the Melba × (*M. floribunda* 821 × Renet Simirenko) family: there are very small fruits (39.3 g) in the form № 98; small fruits – in the forms of № 82, 100 (from 48.5 up to 98.9 g), lower than average – in the form of № 99 (98.9 g). Higher indicators of average fruit weight have genotypes from the family of Golden Delicious tetraploid × OR18T13 [Wolf River × (Wolf River × *M. atrosanguinea* 804/240-57)], which can be explained by the positive influence of the tetraploid maternal initial form (Golden Delicious tetraploid) the large-fruited hybrid posterity. From this family are isolated with fruits of higher than average size (from 186.5 to 196.6 g). The forms of №№ 61, 65, 68, 70, as well as form № 62 with large fruits of average weight of 202.3 g, promising for inclusion in the apple-tree characteristic collections for further use in the breeding process.

4 Conclusion

As a result of long-term research (2005-2019), the most valuable genotypes for breeding were identified among interspecies apple hybrid forms with polygenic and oligogenic types of scab resistance for inclusion in feature collections and further in-depth study based on modern molecular genetic and cytological research methods. There are:

- the most fast-fruited interspecific forms of apple tree: №№ 98, 99, 101, 102, 103, 105, most of which are obtained in hybrid families with the participation of the species *M. purpurea*, as well as the Melba summer variety;
- the forms № 62, 99, 102, 103 with a high average yield (from 29.03 t/he to 40.03 t/he) and high indicators of total yield capacity (from 377.27 t/he to 520.33 t/he);
- the large-fruited form № 62 with fruits of an average weight of 202.3 g, as well as forms № 61, 65, 68, 70 with fruits of higher than average size.

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