

Technology of accelerated breeding of new garden plum varieties (*Prunus domestica* L.)

G.V. Eremin*, A.V. Tikhonova., and O.A. Gorelikova

Krymsk Experiment Breeding Station of VIR, N.I. Vavilov All-Russian Institute of Plant Genetic Resources, 12 Vavilova Street, Krymsk Krasnodar Region, 353384, Russia

Abstract. The article presents the results of the technology of accelerated breeding of new garden plum varieties by grafting on dwarf rootstock BBA 1, which reduce the time of breeding and primary evaluation of varieties to 10 years. For stone crops, the staff of the Krymsk EBS, VIR Branch branch offers a technology that allows to improve the methods of evaluating hybrid seedlings in the process of their growing in a breeding garden using intensification elements. The paper also shows the results of the source material evaluation – isolated hybrid forms of garden plum obtained at the station from directed crosses using parental forms combining in their genotype a number of positive traits: early maturity, large-fruitness, high yield and fruit quality. The technology of accelerated cultivation and evaluation of hybrid seedlings can be used in the breeding of various stone fruit crops.

1 Introduction

Garden plum is one of the main stone crops, considered to be the latest to enter the fruiting season. The breeding of its new varieties requires a long time. It takes from 4 to 7 years from sowing seeds to entering fruiting, and the process of evaluating hybrids requires at least 3-5 years. If we follow the accepted procedure for testing new varieties submitted to the State Commission for Variety Testing before the completion of this process and the inclusion of a new variety in the State Register of Breeding Achievements Approved for Use (zoning), then at least 10 more years pass. Thus, the entire cycle of breeding works carried out is at least 18-20 years. This is a too long period for carrying out the necessary variety change and the introduction of new breeding varieties into production plantings.

The need to accelerate the breeding process in fruit crops is obvious. Leading breeders-fruit growers, starting with I.V. Michurin, proposed various methods to accelerate the evaluation of hybrid seedlings, and, above all, the passage of the juvenile phase of its development [1, 2]. Proposed by I.V. Michurin "mentor method" - grafting a young seedling into the crown of a fruit-bearing tree was used to accelerate and evaluate by different breeders. Kovalenko G.K. (1985), Eremin G.V. (2010), Sedov E.N. (2011) [3-5] and other scientists presented proposals for improving this method.

* Corresponding author: kross67@mail.ru

Researchers of the organization of the Krymsk EBS, VIR Branch for stone fruit crops propose an original technology that allows to significantly improve evaluation techniques in the process of their growing in a breeding garden using intensive type technology. For this purpose, the weakest clonal rootstock BBA 1 is used, which is planted in plantings with a distance between trees of 4×1 m. Annual seedlings of hybrid forms were planted in the garden, in the future, mainly sanitary pruning and crown formation according to the "hedge" type is carried out.

The efficiency of breeding work depends on the source material, that is, obtaining genotypes with the improvement of the specified traits [6, 7]. Breeding is the main way to obtain domestic varieties adapted to the climatic conditions of the regions in which they were bred [8]. On the basis of the Krymsk EBS, VIR Branch, hybrid material in the amount of more than 2500 forms was obtained, concentrated in the genetic collection of the species *Prunus domestica* L., with the help of which elite forms are selected to assess the main economically valuable traits.

2 Objects and methods of research

Research on the study of hybrid forms was carried out in the garden plum plantations on the basis of the Krymsk EBS, VIR Branch. The station territory is located in the Western subzone of the Foothill zone, which is part of the third agro-climatic fruit growing district of the Krasnodar Territory. The plot with experimental plants is a flat area with a slight slope, with drip watering, laid in 2015, the planting scheme is 4×1 m (2500 trees per hectare).

The station's soil cover is characterized by considerable diversity and colourfulness. Compact Kuban and degraded chernozems with poor physical properties prevail. The groundwater lies deep, but the pondweed bugs cause great harm to stone crops.

According to the average long-term data, the average annual air temperature is positive and reaches $+10.6^{\circ}\text{C}$. The sum of positive average daily temperatures for the growing season is $3000\text{-}3600^{\circ}\text{C}$, days with an air temperature above $+10^{\circ}\text{C}$ 195-210, which favorably affects the cultivation of garden plum trees.

The work was carried out from 2018 to 2021. The objects of research were 2500 hybrid forms grafted on the clone rootstock VVA 1, 19 of which were allocated to the elite. As a control, a zoned Stanley variety was taken (catalog number VIR 44097). Laboratory and field experiments were carried out according to the relevant programs and methods of breeding and variety study [9, 10]. Processing of statistical research results was carried out using Microsoft Excel 97 computer program.

3 Results and discussion

The seedlings were grown in a breeding nursery under optimal moisture conditions with fertilizing with a solution of mineral fertilizers by fertigation. Well-developed annual shoots were harvested at the optimal time and oculated in the nursery. A drip watering system was installed in the garden. At the same time, it was considered that the new varieties will be grown at a high agrocenosis, close to what we created in the breeding garden. Before planting in the garden, only seedlings with well-defined traits of "culture" were selected: large leaf, anthocyanin color in glands and chards, resistance to diseases, early leaf fall. Buds for oclusionation were used taken from well-ripened growth shoots.

The resulting annual seedlings were planted in a breeding garden. Seedlings grafted on BBA 1 entered fruiting for 2-3 years after planting, and the commercial yield in a sufficiently large amount began to bring in 3-4 years. From the beginning of fruiting, the

selection of promising hybrid forms was carried out for all the main economically valuable indicators. Since each intervarietal hybrid in the garden is represented by several trees, it is possible to carry out records for phenology, pest and disease damage, winter hardiness, as well as to evaluate fruits by commercial, taste and technological qualities. According to the assessment of commercial qualities and transportability, the possibility of selling fruits in fresh form is determined, and the assessment of manufacturability – the suitability of plums for such types of canning as juice with pulp, compotes, dried fruits [11], as well as suitability for long-term storage, all these factors are important conditions for the selection of hybrid seedlings to the elite. Thus, the breeding nursery and the garden allow to combine the work in primary selection, isolation, and primary testing of selected elites.

Inoculation of garden plum seedlings, on the clone stock of VVA 1, obtained on the Krymsk EBS, showed that all rootstock-graft combinations show compatibility. The influence of the rootstock on the graft affected the vegetation and the passage of phenophases: the beginning of flowering and the beginning of maturation was shifted for several days towards the earlier passage of these phenophases. On average, the flowering of garden plum hybrid forms lasted from 6 to 10 days (Table 1).

Table 1. Phenophases and productivity of trees of garden plum hybrid forms on VVA 1 (planting year 2015, planting scheme 4 × 1 m, 2500 tree/ha).

Hybrid	Origin	Early maturity	Beginning of flowering	Date of picking maturity	Yield, kg/tree			Total yield 2019-2021
					2019	2020	2021	
19-1-58	Anna Shpet s.o.	3-4	12.04	24.08	4.5	4.0	1.0	9,5
19-1-101	Kabardinskaya rannyaya × Monfort	3-4	18.04	20.08	1.5	3.0	3.5	8,0
19-2-8	Stanley × 16-3-248	4	13.04	18.08	4.0	7.0	5.0	16.0
19-2-14	-//-	4	12.04	17.08	2.0	3.0	1.0	6.0
19-2-18	-//-	4	14.04	20.08	3.0	2.5	6.0	11.5
19-2-95	-//-	3-4	21.04	22.08	2.0	3.0	4.5	9.5
19-2-105	-//-	4	21.04	22.08	3.5	5.0	1.0	9.5
19-3-95	-//-	4	14.04	30.08	2.0	3.5	4.0	9.5
19-3-130	-//-	4	18.04	22.08	5.0	1.5	1.0	7.5
19-3-140	-//-	4	17.04	26.08	3.5	2.5	5.0	11.0
19-3-150	-//-	3-4	23.04	21.08	3.5	3.0	4.1	10.6
19-3-159	-//-	3-4	20.04	20.08	1.5	2.0	1.0	4.5
19-2-118	Stanley × Golubaya Mechta	4	21.04	25.08	1.2	3.5	2.2	6.9
19-2-165	-//-	3-4	14.04	20.08	1.5	3.0	3.0	7.5
19-2-174	-//-	3-4	22.04	22.08	2.2	3.0	6.0	11.2
19-3-71	-//-	3-4	12.04	22.08	2.0	4.2	2.0	8.2
19-3-78	-//-	4	20.04	28.08	5.5	5.0	3.0	13.5
19-4-146	-//-	4	15.04	17.08	2.5	2.0	1.0	5.5
19-4-	Stanley ×	3-4	17.04	23.08	2.0	3.5	2.0	7.5

141	Hercules							
Stanley (k)		4	17.04	28.08	3.5	4.5	1.4	9.4
LSD ₀₅		-	-	-	0.9	0.9	1.2	1.9

All grafted seedlings began to bear fruit 2-3 years after planting, which confirmed the previously noted effect of the VVA 1 rootstock [12]. At the same time, significant differences in fertility were revealed, the following hybrids were the most fertile: 19-1-58, 19-1-104, 19-3-120, which gave more than 4 kg from a tree in the 4th year. The assessment of the comparative yield of the selected hybrids varied by year from 1 to 6 kg per tree. The most productive genotypes with a total yield of more than 10 kg per tree for three years were identified: 19-2-8 (16.0 kg/tree), 19-3-78 (13.5 kg/tree), 19-2-18 (11.5 kg/tree), 19-2-174 (11.2 kg/tree), 19-3-140 (11.0 kg/tree), 19-3-150 (10.6 kg/tree). To search for forms with a restrained growth force, biometric indicators of hybrids were determined: tree height, crown width (along and across the row) and bole diameter (Table 2).

Table 2. Biometric indicators of selected hybrid plum forms, 2019-2021.

Hybrid	Tree height, m	Crown width along the row, m	Crown width across the row, m	Bole diameter, cm
19-1-58	1.6	1.1	1.6	5.0
19-1-101	2.0	1.0	1.4	4.8
19-2-8	3.0	1.9	1.9	8.2
19-2-14	3.7	1.7	1.8	9.0
19-2-18	2.5	1.3	1.8	5.7
19-2-95	2.2	1.6	1.8	4.9
19-2-105	1.9	1.1	1.6	5.0
19-3-95	1.6	0.9	1.2	5.0
19-3-129	2.0	1.3	1.2	5.8
19-3-140	2.8	1.7	1.6	5.3
19-3-150	2.6	1.2	1.7	5.5
19-3-159	3.0	1.7	2.2	6.2
19-2-118	2.8	1.6	1.8	7.0
19-2-165	2.0	1.5	1.6	5.5
19-2-174	2.7	1.2	1.4	6.6
19-3-71	2.2	1.2	1.4	4.6
19-3-78	1.6	1.0	1.3	3.5
19-4-146	1.9	1.1	1.2	5.0
19-4-141	2.3	1.6	1.4	6.6
Stanley (k)	2.8	1.3	1.6	6.5
LSD ₀₅	0.4	0.2	0.2	0.9

The height of the trees varied from 1.6 to 3.7 m. With the weakened growth force of trees, the following hybrid forms stood out: 19-1-58, 19-1-101, 19-2-18, 19-2-105, 19-3-95, 19-3-129, 19-3-150, 19-2-174, 19-3-71, 19-3-78, 19-4-146, which, in terms of growth indicators, were at or below the control Stanley variety.

It was found that of the total number in the hybrid population by maturation terms: early – 1%, medium-early – 4%, medium-term - 70%, medium-late – 20%, late – 5%. The selected hybrid forms of medium and late maturation are large-fruited and the sources of these traits, the results are shown in Tables 1, 3. All of them were characterized by large fruits at the level and above the control Stanley variety, and in terms of fresh quality they exceed the control variety indicators. It is revealing that inoculation on dwarf rootstock

VVA 1 did not have a negative impact on the size and quality of fruits. All selected elite forms had a fetal mass of over 40 g, but the most large-fruited hybrids with a fetal mass of over 50 g were the following: 19-3-150 (50.6 g), 19-2-18 (51.1 g), 19-2-165 (51.7 g), 19-4-141 (55.3 g), 19-2-174 (59.5 g).

The products of fruit processing of hybrid forms were evaluated by the quality of canned food: juice, compote, dried fruits, which were not inferior to the control Stanley variety, and even surpassed in some indicators, which positively affects the overall assessment of fruit processing quality.

For garden crops, one of the important indicators is disease resistance. The most common diseases of garden plum in the conditions of the Krasnodar Region are pustular spot and monilial blight. Identified 19 elite forms, which in natural conditions are affected by these diseases to a small extent (up to 1 point – single lesion, up to 1% of leaves).

Table 3. Assessment of fruit quality of plum hybrids, 2019-2021.

Hybrid	Average fruit weight, g	Tasting assessment of fresh fruits, points	Canned food quality, points		
			juice	compote	dried fruits
19-1-58	47.7	4.7	4.5	4.6	-
19-1-101	40.7	4.7	4.8	4.4	4.4
19-2-8	45.5	4.6	4.5	4.3	4.3
19-2-14	42.6	4.5	4.5	4.5	4.4
19-2-18	51.1	4.7	4.5	4.6	4.6
19-2-95	46.0	4.6	4.5	4.4	4.3
19-2-105	40.7	4.7	4.5	4.5	4.7
19-3-95	40.8	4.5	4.4	4.4	4.5
19-3-129	43.9	4.6	4.4	4.5	4.7
19-3-140	47.7	4.8	4.5	4.6	4.6
19-3-150	50.6	4.7	4.7	4.7	4.6
19-3-159	48.3	4.7	4.5	4.5	4.7
19-2-118	47.6	4.8	4.4	4.3	4.8
19-2-165	51.7	4.6	4.5	4.5	4.6
19-2-174	59.5	4.6	4.6	4.5	4.5
19-3-71	42.0	4.7	4.5	4.6	4.6
19-3-78	41.0	4.6	4.8	4.6	4.4
19-4-146	42.0	4.7	4.4	4.5	4.2
19-4-141	55.3	4.6	4.6	4.6	4.7
Stanley (k)	42.2	4.4	4.7	4.6	4.7
LSD ₀₅	3.6	0.1	0.1	0.1	0.2

Thus, the results of the primary study necessary for the transfer of the best elites as candidates for varieties were obtained already in the intensive garden for 6 years after planting in the primary test garden, where hybrids were grown using intensive type technology. Due to the exclusion of new varieties in the breeding scheme by primary study of seedlings in the breeding garden, the assessment of breeding material is accelerated up to 10 years. Additional costs for growing seedlings before they enter fruiting, further rejection of unpromising forms, as well as reproduction of 5-10 plants are excluded from the breeding process scheme.

4 Conclusions

As a result of the study of 2500 hybrid forms, 19 elites were identified according to agronomic characters. Of these, a group of hybrids combining in their genotype a complex of economically valuable traits for early fertility (for 3-4 years); large-fruitiness (fruit weight > 50 g); high estimates for technological processing: juice, compote, dried fruits (4.5 and above points); disease resistance (up to 1 point): 19-2-18, 19-3-140, 19-3-150, 19-2-165, 19-2-174, 19-4-141, representing the prospect as elite forms, as candidates for varieties.

The technology of growing hybrid seedlings of garden plum by grafting on dwarf rootstock BBA 1 allows to reduce the time of breeding and initial assessment of new varieties up to 10 years. Grafting of cuttings from annual seedlings of garden plum does not lead to a decrease in size and deterioration in fruit quality.

The technology of accelerated cultivation and assessment of hybrid seedlings on the BBA 1 clone rootstock in intensive type plantings can be used in the breeding of various stone fruit crops.

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