

Promising garden plum varieties of Krymsk EBS, VIR Branch breeding for prunes production

*Gennady Eremin, Anna Tikhonova, and Olga Gorelikova**

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

Abstract. In the garden plum assortment of Russia, until recently there was an almost complete absence of varieties with fruits suitable for making high-quality prunes, which prevented expansion of the production of this valuable product. This necessitated the selection of garden plum varieties suitable for prunes production in a number of scientific institutions of the country, including the Krymsk EBS, VIR Branch. As a result of the works carried out at the station, the following results were obtained: In the gene pool of garden plum, Yubileynaya Sochinskaya and Blufry varieties were allocated. They combine high qualities of fruits for preparing prunes with good adaptability to the climatic conditions of South Russia, which have been used as selectionally valuable traits sources in programs of new dry fruit varieties' creation. High-tech dry-fruit plum varieties combining adaptability with productivity and high prunes quality were selected; 8 of them are included in the State Register of the Russian Federation. For different cultivation technologies of new plum varieties, zoned clone rootstocks bred on Krymsk EBS, VIR Branch are recommended: medium-grown drought-resistant with good trees' root system anchoring (for mechanized fruit harvesting) - Zarevo, Evrika 99, Druzhba; small-grown - VVA 1, VSV 1, Best.

1 Introduction

Garden plum is one of the leading stone fruit crops in Russia. Its fruits are used both for fresh consumption and to produce canned food. Among preserved plum products, the most valuable and popular are dried fruits: prunes - from fruits of "greengage" varieties and "dried plums" - from fruits of other varieties of this crop [1 - 4].

Since our country does not have fully established industrial production of dried fruits from plum fruits, until recently prunes were imported from other countries - Bulgaria, Serbia, Yugoslavia, France, USA [5 - 8]. However, due to the imposition of sanctions on the importation of these products from abroad, their supply has significantly decreased, and the problem of import substitution of such products has emerged. Today, the confectionery industry and the population is experiencing a shortage of dried fruits, including prunes.

* Corresponding author: gorelickova.o@yandex.ru

After the collapse of the USSR, there were no regions in Russia with established full-scale production of dried fruits. At the same time, in a number of regions of Russia there are all conditions for plum cultivation and its high-quality fruits growing valuable for prune manufacturing. So, dried fruits from plum grown in the North Caucasus have repeatedly won prizes at international exhibitions. In the USSR prunes were produced mainly in Moldova and Transcaucasian republics. Until recently, the increase in the area of plum gardens in the Russian Federation was constrained by the absence of this crop's varieties in the assortment combining the high quality of fruits with adaptability, which is the most relevant nowadays. Therefore, work on the creation of such varieties has been started in a number of scientific institutions since the beginning of the 21st century, which steadily continues today.

2 Materials and methods of research

The work was carried out at the Krymsk Experiment Breeding Station (Krymsk EBS), VIR Branch from 2017 to 2020. The station is located at 35 m above sea level in the Western part of the foothill zone of Krasnodar Region. Station's topsoil is characterized by considerable variety and color diversity. Joined Kuban and degraded chernozems with poor physical properties prevail. The territory of the station is included in the third agroclimatic district of Krasnodar Krai. According to long-term data, the average annual air temperature is positive and reaches +10.6° C. The sum of positive daily average temperatures for the growing season amounts to 3000-3600°, days with air temperature above +10°C - 195-210, which favorably affects the cultivation of garden plum trees.

The first variety study segment was laid in 2015 according to the scheme of 5 × 1.5 m (1333 trees/ha), rootstock VVA 1, with the use of drip irrigation, studied varieties of Krymsk EBS breeding: Ballada (43904)*, Beglyanka (43908)*, Bolshoy Priz (45392)*, Vengerka Novaya (45393)*, Golubaya Mechta (45394)*, Debut (43933)*, Kubanskiy Karlik (43979)*, Kubanskaya Legenda (43981)*, Kubanskaya Rannyaya (28536)*, Kubanskaya Jubileynaya (45395)*, Lider (45398), Naslednitsa (No. Krymsk EBS 27024), Osenniy Suvenir (44062)*, Prestizh (45400)*, Slastena (No. KEBS 27053), Sinyaya Ptitsa (44090)*, (*No. of the VIR catalogue).

The second segment of varietal study without irrigation was laid in 2013 according to the scheme of 5 × 3 m (666 trees/ha) using medium-grown rootstock Zarevo, Evrika 99, Druzhba; scheme 5 × 1.5 m (1333 trees/ha) using small-grown rootstock VVA 1, VSV 1, Best; studied varieties: Ballada, Kubanskaya Legenda, Kubanskaya Rannyaya, Sinyaya Ptitsa.

Control for early, medium-early varieties - Kabardinskaya Rannyaya, for medium and late - Stanley.

The main records and observations were carried out in accordance with the "Program and Methods of Variety Study of Fruit, Berry and Nut Crops" 1999 [9]. The processing of statistical research results was carried out using dispersion analysis by the "Field Experiment Method" 1985 [10], with the help of Microsoft Excel 97 computer program.

The technological assessment was made in accordance with the requirements of GOST 32896-2014, GOST 32105-2013, GOST R 54680-2011, required for each type of processed products. Biochemical evaluation of garden plum fruits was carried out in the testing laboratory of storage and processing of fruits and berries FSBSI North-Caucasian FSC of Horticulture, Viticulture and Winemaking in accordance with the requirements of GOST 28562-30, GOST 25555.0-82, GOST 8756.13-87.

3 Results and Discussion

In previous years, at the first stage of breeding work we have identified Jubileynaya Sochinskaya and Blufry varieties in the plum gene pool focused on Krymsk EBS, VIR Branch as sources combining high-quality fruits with adaptability for prunes preparation [11]. When breeding new dried fruit plum varieties, special attention was paid to taste, technological and commercial qualities of the product obtained by plum drying, as well as fruits ripening periods (from early to late) to create a conveyor ensuring a uniform flow of products to processing enterprises. Today, high quality productive varieties have been created at Krymsk EBS: early — Kubanskaya Rannyaya, Debut, Lider; medium — Kubanskiy Karlik, Kubanskaya Jubileynaya, Vengerka Novaya, Sinyaya Ptitsa, Beglyanka, Bolshoy Priz; late — Ballada, Kubanskaya Legenda, Prestizh, Naslednitsa, Golubaya Mechta, Osenniy Suvenir. These varieties allow to provide 2.5-3 months of continuous receipt of raw materials to enterprises performing plum fruits drying (Figure 1).

Variety	10.07	20.07	01.08	10.08	20.08	01.09	10.09	20.09
Kubanskaya Rannyaya	█							
Debut	█	█						
Lider	█	█	█					
Kabardinskaya Rannyaya (st)		█	█	█				
Kubanskiy Karlik			█	█	█			
Kubanskaya Jubileynaya			█	█	█			
Vengerka Novaya				█	█	█		
Sinyaya Ptitsa					█	█		
Beglyanka						█	█	
Bolshoy Priz							█	█
Ballada								█
Kubanskaya Legenda								█
Prestizh								█
Naslednitsa								█
Stanley (st)								█
Golubaya Mechta								█
Osenniy Suvenir								█

Fig. 1. Ripening timing of the garden plum fruits, (average for 2017-2020)

One of the most important problems in the breeding of dried fruit plum varieties is the need to combine high qualities of fruits with adaptability, since the climatic conditions of southern Russia are very changeable and stressful situations occur periodically: in the middle of winter, the temperature can drop below -30°C , at the end of winter, return frosts up to -20°C are often observed. In summer, droughts occur, and the temperature rises to $+40^{\circ}\text{C}$ and above. Over the years of study, more temperature-stress-resistant varieties have been identified. Beglyanka variety is distinguished by resistance to return frosts at the end of the winter period. Varieties with high winter resistance were also distinguished: Ballada, Vengerka Novaya, Kubanskaya Legenda, Kubanskaya Rannyaya, Sinyaya Ptitsa. Kubanskiy Karlik variety was quite winter-resistant in the Moscow region [12]. In terms of winter resistance, most new varieties are close to the standard Stanley variety, and some significantly outperform the other standard variety - Kabardinskaya Rannyaya [13, 14].

All varieties of studied dried fruit plums did not have sufficient drought resistance, but significantly surpassed the standard varieties Kabardinskaya Rannyaya and Stanley [2]. The rootstock is the most important role in the formation of drought resistance. In this regard, Zarevo, Druzhba, VSV 1, Best are distinguished among clone rootstocks.

New varieties are not inferior or even somewhat superior to the best zoned variety in quality of manufactured prunes - Stanley. Particularly high-quality prunes were obtained when drying fruits of such varieties as Kubanskaya Legenda, Vengerka Novaya, Golubaya Mechta. The best promising prunes are obtained from large-fruited varieties: Beglyanka, Bolshoy Priz, Kubanskaya Jubileynaya, Osenniy Suvenir, Prestizh, superior in this indicator the standard Stanley variety (table 1).

Table 1. Technological assessment of processing products from the garden plum fruits, average for 2017-2020 (Krymsk EBS, VIR Branch, planting year 2015, 5 × 1.5 m planting scheme, VVA 1 rootstock)

Variety	Origin	Tasting score, points			
		dried fruits	juice with pulp	compote	frozen fruits
Ballada	Kabardinskaya rannyaya × Jubileynaya Sochinskaya	4.4	4.9	4.0	4.5
Beglyanka	Gorkusha × Althan's Reine-Claude	4.7	4.5	4.4	-
Bolshoy Priz	Kabardinskaya Rannyaya × Sopernitsa	4.6	4.8	4.3	4.8
Vengerka Novaya	Vengerka Kavkazskaya clone	4.6	4.3	4.8	4.2
Golubaya Mechta	Stanley x Sentyabrskaya	4.8	4.6	4.6	4.0
Debut	Elite 2-21-32 × Kabardinskaya Rannyaya	4.0	4.6	4.3	-
Kabardinskaya Rannyaya (c)	Anna Szpet v.s.	4.0	3.9	4.0	4.0
Kubanskaya Legenda	Althan's Reine-Claude × Jubileynaya Sochinskaya	4.4	4.0	4.3	4.4
Kubanskaya Rannyaya	Vengerka Venskaya v.s.	4.0	4.0	4.0	-
Kubanskaya Jubileynaya	Alvena x Zainap	4.6	4.4	4.2	-
Kubanskiy Karlik	Wangenheim Prune × mixture of dried fruit varieties' pollen	4.5	4.5	4.2	-
Lider	S/c Kabardinskaya Rannaya	4.5	4.5	4.0	-
Naslednitsa	Stanley v.s.	4.4	4.7	4.5	4.3
Osenniy Suvenir	Bluefry variety clone	4.6	4.9	4.6	4.5
Prestizh	Althan's Reine-Claude × Jubileynaya Sochinskaya	4.6	4.9	4.6	4.8
Slastena	Elite 2-21-32 × Vengerka Azhanskaya	4.0	4.3	4.3	4.8
Sinyaya Ptitsa	Kabardinskaya Rannyaya × Jubileynaya Sochinskaya	4.5	4.5	4.5	4.2
Stanley (c)	Vengerka Azhanskaya × Velikiy Gertsog	4.2	4.5	4.4	4.8

It should also be noted that high-quality fruits of the best dried fruit varieties are good for other valuable types of canning: juices with pulp, compotes, frozen fruits. In addition, all dried fruit varieties are good for fresh consuming (table 2). The taste of fruits is largely determined by the number and ratio of different types of sugars and acids [15]. Soluble dry substances in fruits ranged from 13% (Kubanskaya Rannyaya) to 21% (Osenniy Suvenir); the sum of sugars from 8.7% (Kubanskaya Rannyaya) to 19.1% (Osenniy Suvenir).

Table 2. Estimation of economic value of garden plum varieties, average for 2017-2020, (Krymsk EBS, VIR Branch planting year 2015, 5 × 1.5 m planting scheme, VVA 1 rootstock)

Variety	Tasting score of fresh fruits, points	Main biochemical indicators				Fruit weight, g	Yield, t/ha
		soluble dry matter, %	sum of sugars, %	acidity, %	s/a index		
Ballada	4.6	16.3	10.6	1.38	7.7	38.0	12.8
Beglyanka	4.3	17.7	11.3	0.53	21.3	45.0	9.2
Bolshoy Priz	4.7	14.8	10.8	1.27	8.5	54.8	16.0
Vengerka Novaya	4.8	18.3	11.6	0.59	19.7	34.5	12.7
Golubaya Mechta	4.5	14.9	13.1	0.69	18.9	34.2	19.5
Debut	4.3	16.2	13.5	0.46	29.3	46.3	13.9
Kabardinskaya Rannyaya (c)	4.8	14.0	11.3	0.66	17.1	36.4	17.3
Kubanskaya Legenda	4.8	19.2	12.6	0.65	19.4	35.0	19.6
Kubanskaya Rannyaya	4.4	13.03	8.7	0.85	10.2	39.8	10.7
Kubanskaya Jubileynaya	4.6	18.6	13.7	0.92	14.9	50.7	9.6

Kubanskiy Karlik	4.7	19.9	13.1	0.72	18.1	32.5	6.7
Lider	4.6	15.3	10.4	0.82	12.7	55.0	11.8
Naslednitsa	4.5	17.0	12.7	0.90	14.1	46.4	15.6
Osenniy Suvenir	4.8	21.0	19.1	0.78	24.5	56.2	21.2
Prestizh	4.7	15.7	14.1	0.92	15.3	45.0	9.3
Slastena	4.3	19.2	13.8	0.65	21.2	40.0	7.3
Sinyaya Ptitsa	4.3	15.8	12.7	0.61	20.8	36.8	14.3
Stanley (c)	4.8	18.4	12.9	0.56	23.0	40.0	19.6
LCD ₀₅	-	0.8	0.7	0.1	1.9	2.6	1.5

An important technological indicator reflecting the taste qualities of fruits is the sugar-acid index (SAI). The greater the SAI, the higher the taste properties of the fruits. Among the varieties in sugar-acid relation, Debut (29), Osenniy Suvenir (24,5), Beglyanka (21,3), Slastena (21,2), Sinyaya Ptitsa (20,8) varieties stood out. Along with the standard varieties Kabardinskaya Rannyaya and Stanley, the following varieties with high taste and commercial qualities stood out: Vengerka Novaya, Kubanskaya Legenda, Kubanskiy Karlik, Osenniy Suvenir, Bolshoy Priz, Prestizh.

Productivity plays a decisive role in the evaluation of new dry-fruit plum varieties, which largely depends on the technological suitability for their use in modern cultivation technologies [16, 17]. Currently, the Russian Federation uses two types of technologies: energy-saving, based on the use of mechanized trees care - fruit harvesting; and intensive technology with thickened plantings structure using small-grown varieties and clone rootstocks. In this case, harvesting is carried out either manually with the help of a fruit harvesting platform or aggregates like grape harvester VSK-3M.

To the greatest extent, the first method is widespread using the generally accepted density of planting and cleaning with a shaker type VUM-15 [18, 19]. All dried fruit varieties were suitable for harvesting with a shaker, since they have dark color of the skin, strong fruit skin and pulp, their relatively simultaneous ripening. More complete fruits' shaking is achieved in trees having a thick crown, where the fruits are set mainly on growing twigs closer to thick skeletal branches. Vengerka Novaya, Kubanskaya Legenda, Debut, Lider, Stanley, Naslednitsa can be attributed to such varieties.

In technology of the second type, small-grown varieties have the advantage, such as Kubanskiy Karlik, Debut, using small-grown clone rootstock - VVA 1, VV 1, Best. This allows to reduce the height of the tree to 2.5-3 m and carry out manual harvesting without the use of ladders [1].

Productivity of new varieties was studied in both technologies using different rootstocks. At the same time, it was found that almost all varieties were suitable for cultivation by these technologies and were quite productive (table 3).

The varietal-rootstock combinations for yield over 12 t/ha using rootstocks Zarevo, Evrika 99, Druzhba in varieties Ballada and Sinyaya Ptitsa were distinguished. New dry-fruit varieties on small-grown rootstock are more productive in early fruiting years. The varietal-rootstock combinations were distinguished with the use of small-grown clone rootstocks by the yield of over 13 t/ha in varieties Sinyaya Ptitsa, Ballada and Kubanskaya Legenda.

Plum varieties with dense fruits are preferred in modern intensive commercial plantings as they are less susceptible to damage during harvesting and transportation, resulting in the possibility of storage time of up to three months and longer in fruit storage facilities at a temperature of +5 °C and have a smaller percentage of tainted fruits. Such varieties superior to the standard Stanley variety include: Beglyanka, Golubaya Mechta, Naslednitsa, Osenniy Suvenir.

Table 3. Yields t/ha of plum varieties on various clone rootstocks, the average yield for 2017-2020 (Krymsk EBS, VIR Branch 2013 planting)

Variety	Medium-grown rootstock (5 × 3 m planting scheme)			Small-grown rootstock (5 × 1.5 m planting scheme)		
	Zarevo	Evrika 99	Druzhba	VVA 1	VSV 1	Best
Kubanskaya Rannyaya	6.1	6.4	7.5	12.3	15.1	10.7
Kabardinskaya Rannyaya, c	11.5	9.5	12.2	21.5	12.1	13.2
Ballada	15.4	18.8	15.6	18.0	-	-
Kubanskaya Legenda	8.1	9.7	5.5	25.7	13.5	17.7
Sinyaya Ptitsa	12.2	14.4	16.8	18.3	17.3	-
Stanley, c	13.3	14.7	17.0	16.4	12.0	16.8
LCD ₀₅	2.2	2.9	3.1	2.9	1.6	2.7

Note:

1 - Ballada variety is incompatible with VSV 1, Best rootstock, options unavailable

2 - Sinyaya Ptitsa variety is incompatible with Best rootstock, option unavailable

Essentially, all studied dried fruit plum varieties are excellent universal varieties and they can be recommended for laying in industrial plantations of the southern fruit growing zone of Russia. Optimal rootstock for usage are Evrika 99, Druzhba, VVA 1, Best, which are relatively unpretentious to the choice of soils and also give the opportunity to use variety-rootstock combinations in intensive technologies with the use of mechanized fruit harvesting.

4 Conclusions

1. New dried fruit plum varieties were produced on the Krymsk EBS, allowing to grow raw materials for the manufacture of high-quality prunes and dried plum on an industrial basis in the conditions of the southern fruit growing zone of Russia. The most productive varieties were: Ballada, Kubanskaya Legenda, Sinyaya Ptitsa, both on medium-grown and small-grown rootstock.

2. New dry-fruit varieties of the Krymsk EBS breeding have high adaptability, which allows to recommend them for production testing to expand the industrial crop zone in steppe regions of the North Caucasus, Crimea, Lower Volga region.

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