

Formation and evaluation of the genefund of subtropical cultures in the Nikita Botanical Gardens

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Abstract. The article presents the stages of formation and the results of the study of the genefund of persimmon, ziziphus, olives and figs in the Nikita Botanical Gardens. Based on the results of many years research, the best cultivars have been selected that are donors of economically valuable characteristics. Among the cultivars of foreign selection, the following cultivars are selected according to the best complex of economically valuable characteristics: persimmons (Fuyu, Kiara, Hiakume, Hachia, Rojo Brillante, Sharon, Batumsky II, etc.), ziziphus (Zhu-Tau-Zao, Chinese 2A, Chinese 93, Ta-Yan-Zao, Ya-Zao), olives (Ascolano, Tiflis, Coreggiolo, Della Madonna, Otur, etc.), figs (Randino, Grosse Violette de Bordeaux, Castle Kennedy etc.). As a result of directed interspecific and intraspecific hybridization of the best foreign cultivars, a significant hybrid fund was formed and new cultivars were bred, which surpass foreign cultivars in a number of characteristics. Among them are persimmon cultivars: Stella, Zolotistaya, Zvezdochka, Mechta, Nikitskaya Bordovaya, Yuzhnaya Krasavitsa, Ukrainka, Suvenir Oseni, Rossiyanka, etc., cultivars of ziziphus Koktebel, Meteor, Tavrika, Yalita, Sinit, Radoslav, Konfetny, etc., cultivars of olives: Manita, Skorospelaya, Violetta, Nikitskaya, Krymskaya Prevoskhodnaya, etc., fig cultivars: Yantarny, Sukhofruktovy Nikitsky, Podarok Oktyabru, Sabrucia Rozovaya, etc.

1 Introduction

Obviously, the future of plant breeding and, consequently, agriculture on the scale of the global food supply will depend on the hereditary potential of plant genetic resources, which are now stored in gene banks [1].

The loss of genetic diversity of some of the world's crops has accelerated in recent decades, and many crops are becoming increasingly susceptible to disease, pests and environmental stress. The current negative situation prompted the world scientific community to decide to create a global network of gene banks to provide breeders with the genetic resources necessary to develop more resistant crops [2].

The main catalysts for genetic erosion are biotic and abiotic processes of the

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environment (urbanization, intensification, etc.) [3, 4]. A significant decrease in the level of genetic diversity, various species of crops, leads to the need to preserve as many genotypes as possible [5, 6]. This task can be accomplished by preserving different plants in collections "in situ", "ex situ" and "in vitro". At present, botanical gardens are one of the main world centers in the work on the preservation of genotypes [7].

Genetic diversity enables breeders to select material in the form of donor plants with economically valuable characteristics for plant breeding and improvement [8]. Genefund collections are the basis for breeding improvement of existing cultivars and the basis for the obtaining of hybrid material. They are formed due to the cultivars introduced from other geographic regions and countries, as well as cultivars and hybrids of own selection.

Nikita Botanical Gardens is one of the largest centers for the conservation of biodiversity of fruit, ornamental, medicinal and aromatic crops. On its basis, significant collections of cultivated and wild-growing plants "in situ" and "ex situ", "in vitro" and in the form of DNA) have been formed [7].

The genefund collection of subtropical fruit plants in the Nikita Botanical Gardens is the most extensive in Russia. It is represented by such crops as persimmon, olive, ziziphus, feijoa, pomegranate, figs, kiwi, etc. The genetic diversity of cultivars and hybrids of these crops provides significant opportunities for their breeding improvement. This article is devoted to the formation of genetic collections of subtropical fruit crops and the study results for the collection fund of persimmon, olive, ziziphus and figs.

2 Materials and methods

The object of the research was the gene collections ("in situ") of persimmons, ziziphus, olives and figs. The gene collections are located in climatic conditions characterized as dry subtropics, the average annual temperature is + 13.7 ° C. The annual amount of precipitation is 680 - 780 mm. The absolute minimum air temperature is -15 ° C, and the average of the minimums is -5...-7 °C. Collection areas of subtropical crops are located 60 - 800 m from the Black Sea coastline at altitudes from 30 to 170 meters above sea level. Regarding the cardinal points, the prevailing exposure is south and southeast. The steepness of the slopes of the sections varies from 1° to 12°. Edaphic conditions are characterized by the presence of brownish-gray, gray, low-carbonate, powerful, medium-heavy loamy, weakly and medium-gravelly crushed stone, planted soils [9].

The study and phenological description of plants was carried out in accordance with the "Program and methodology for variety study of fruit, berry and nut crops" [10]. Period of work is 2015-2020.

3 Results and discussion

Eastern persimmon (*Diospyros kaki* Thunb.) is one of the most widespread industrial crops in subtropical fruit growing in the world. The high popularity of persimmon fruits among consumers is explained by its high taste and attractive appearance. The total sugar content in ripen fruits reaches 25.9%, mainly fructose and glucose. In addition, the fruits are rich in vitamins (C, P), caratenoids and micro elements.

In 2019, the global harvest of persimmon was 4.4 million tons. The top three leaders in the production of persimmons are China, South Korea and Japan. In 2019, China produced 3.2 million tons of fresh fruit. In South Korea and Japan this figure was 316 thousand tons and 208 thousand tons, respectively [11].

For the first time, persimmon seeds were brought to the Nikita Botanical Gardens in 1819, but it was not possible to get seedlings from them. Only by the end of the 19th

century it was possible to get vegetative seedlings growing in the open field and in 1901 the first plantation with an area of 0.05 hectares was laid in Nikita Botanical Gardens. In 1937 the Department of Subtropical Cultures was founded in the Nikita Botanical Gardens, this served the active development and further formation of the persimmon gene collection [12].

Currently, there are more than 120 cultivars and hybrid forms in the collection plantations of persimmons. Plants obtained as a result of many years active work of breeders are the basis of the gene collections in the Nikita Botanical Gardens, their total number is 57.4%. The number of introduced foreign cultivars is 42.6%.

The most prominent genotypes are bred due to interspecific and intraspecific hybridization with species such as *D. kaki* Thunb. and *D. virginiana* L. By 2020 the Register of Breeding Achievements of Russia has already included 10 persimmon cultivars bred in the Nikita Botanical Gardens, among them: Stella, Zolotistaya, Zvezdochka, Mechta, Nikitskaya Bordovaya, Yuzhnaya Krasavitsa, Suvenir Oseni, Ukrainka and Rossiyanka.

For the development of industrial gardens of intensive type in the south of Russia, new highly productive, sustainable fruit cultivars are needed. Therefore, one of the main aims of studying the existing collection is the description and identification of genotypes for a complex or individual economically valuable characteristics, such as productivity, winter hardiness, fruit quality, disease resistance, as well as their adaptive potential in the climatic conditions of the Crimea and southern Russia.

The main criteria for selection are: the presence or absence of large-fruited, fruit astringency at technological maturity, early ripening, high winter hardiness, good drought resistance, resistance to fungal diseases and pests.

The collected material on the main economically valuable characteristics allows to make a comparative analysis and identify the most promising cultivars to use them in the further breeding process as donors of economically valuable characteristics, as well as to introduce them into the production process to obtain a high-quality and consistently high yield (Table 1).

Table 1. Promising persimmon cultivars of the gene collection of the NBS-NSC.

Characteristics	Cultivar
Large-fruited	Batumsky II, Mechta, Hachia, Zolotistaya, Rojo Brillante, Konkurent, Zamanchivy, Hiakume, Sharon
Lack of astringency	Triumf, Prevoskhodny, Nadezhda, Fuiyu, Kiara, Nakhodka, Prelestnaya, Nikitsky Prevoskhodny, Sharon, Krymchanka 55
Early ripening	Yuzhnaya Krasavitsa, Sputnik, Shokoladnaya, Doch Saburozy, Mechta, Zolotistaya, Zvezdochka, Ukrainka, Hiakume, Izobilnaya
High winter hardiness	Rossiyanka, Nikitskaya Bordovaya, Yuzhnaya Krasavitsa, Zorka, Zolotistaya, Suvenir Oseny, Nakhodka, Yuzhnoberezhnaya, Zolotaya Osen, Krymchanka

Ziziphus belongs to the genus *Zizyphus* Mill., to the buckthorn family - Rhamnaceae R. Br. For widespread cultivation, *Zizyphus jujuba* Mill. is of great interest.

For the first time, ziziphus was brought to the Nikita Botanical Gardens from China in 1953. The existing collection of zizyphus includes 6 species of genus *Zizyphus* Mill. and 123 cultivars and forms. 7 cultivars from them are the selection of the Nikita Botanical Gardens [4].

Zizyphus is a branchy shrub or deciduous tree. *Zizyphus* fruits have high medicinal and dietary properties. It should be noted that other parts of plants - shoots, leaves, flowers are also carriers valuable properties. *Zizyphus* is drought-resistant and winter-hardy, little damaged by diseases, early fruiting. A distinctive feature is high and regular productivity. To ensure the duration of the consumption period of perishable products, such basic methods of storage and processing as drying, freezing, heat sterilization, chemical sterilization and others are used [13].

Ziziphus is cultivated in small areas. Successful cultivation depends on the selection of plots, the selection of an assortment and adherence to all agrotechnical methods for caring for plants. The natural conditions of the Crimea and a number of areas in the southern region of Russia are favorable for the cultivation of this crop.

In Nikita Botanical Gardens, the main direction in the selection of ziziphus is to obtain large-fruited, early ripening cultivars with a high content of biologically active substances, undersized with a small number of thorns.

Based on the results of a long-term agrobiological study of the ziziphus gene collection in the Nikita Botanical Gardens, 7 promising cultivars for using in production have been selected.

Table 2. Promising cultivars for use in production.

Cultivars	Characteristics
Konfetny	Ripening period - very early (1st decade of September), high and regular yield - 165 kg / ha. Medium-fruited, average fruit weight 5.0 g, rich in biologically active substances, dried on a tree.
Radoslav	The ripening period is very early (II decade of September), high-yielding - 138 kg / ha. Fruits with an average weight of 7.0 g, universal use of fruits.
Sinit	Ripening period - early (I-II decade of September), regular, high yield - 135 kg / ha. Medium-fruit, average weight - 5.0 g, universal use of fruits.
Yalita	Ripening period - early (II decade of September). High-yielding variety - 123 kg / ha. Large-fruited, with an average weight of the fruit - 9.7 g. Universal use of fruits.
Tavrika	Ripening period - average (I decade of October). The yield is high - 133 kg / ha. Medium-sized fruits - 5.2 g, high content of biologically active substances, universal use of fruits.
Meteor	Ripening period - average (I decade of October). High-yielding, average yield - 120 kg / ha. The average fruit weight is 5.5 g. The fruits are suitable for fresh and canned consumption.
Koktebel	Ripening period - late (3rd decade of October - 1st decade of November). The yield is high - 193 kg / ha. Average fruit weight - 36.0 g. Fruits are suitable for consumption in canned form.

The olive (*Olea europaea* L.) belongs to the genus *Olea*, family *Oleaceae* [14]. Currently, the olive is one of the most cultivated fruit species. The area under this crop in 2019 amounted to 10.6 million hectares, and the gross olive harvest reached 19.5 million tons, of which 5.97 million tons were produced in Spain, 2.19 million tons - in Italy, 1.91 million tons - in Morocco, 1.53 million tons - in Turkey, 1.23 million tons - in Greece. The rest of the countries produce olives in small quantities for their own consumption [11].

Olives are mainly cultivated in an extensive way. Old cultivars and their hybrids are often cultivated. In this regard, the work on the obtaining and studying of the olives genefund and the intensification of work on the selection of new cultivars suitable for intensive gardening is acquiring a great role.

On the territory of Russia, the olive has been grown for a long time. It was introduced by the ancient Greeks and Genoese. From the first years of the foundation of the Nikita Botanical Gardens, the purposeful creation of the olive genefund began. The collection was formed mainly through the introduction of seedlings and cuttings from European countries: Italy, Spain, France, Albania, as well as the countries of North Africa. The scientific study of the gene collection began in 1927. At this time, the collection was insignificant and consisted of 25 cultivars, and by the 60s it managed to increase to 62 cultivars. Since 1970, the gene collection has been regularly replenished with new cultivars and hybrid forms. In 1987, the olive's genefund had already 160 cultivars and forms and was the largest in the USSR.

To date, the collection fund of olives in the Nikita Botanical Gardens is represented by 229 cultivars. More than 1000 self-rooted seedlings are at the stage of primary cultivar study. Based on the results of many years breeding work, the most interesting cultivars were selected in terms of ripening (Table 3), in the direction of fruit use (Table 4), as well

as cultivars that are distinguished by large-fruited, high yield, increased frost resistance and a high content of olive oil in fruits (Table 5).

Table 3. Grouping of olive cultivars by ripening dates.

Early cultivars, ripening at the end of October
Krymskaya, Krymskaya Rannyaya, Chernaya Rannyaya, Konservnaya, Skorospelaya, Manita, Nikolina, Krymskaya Zvezda, Appetitnaya, Primorskaya, Progress, Stolovaya, Universalnaya, Yubileynaya, Nikitskaya Krupnoplodnaya, Nikitskaya, Kolkhoznitsa, Della Madonna, Otur, Bolshaya Ispanskaya, Gordal, Obilnaya, Kalinjot, Gyukates, Pulyazekin, Vaes Pekina, Bakinsky 8 , ets.
Medium ripening cultivars, ripening in the first half of November
Aglandau, Tossiyskaya, Tolgomskaya, Miskhorskaya 1, Pikvales, Nadzhviyskaya, Sevillano, Chemberikendskaya, Ofelankos, Nikitskaya 4, Stoykaya, Gorvala, Bidza, Santa-Caterina, Bakinskaya 25, Nevadillo, Bakinskaya 51, Tlemsen, Poroslevaya 2, Poroslevaya 1, Kormono, Italyanskaya, Bakinskaya 17, Nisijot, ets.
Mid-late cultivars, ripening in the second half of November
Nikitskaya 3, Dalmatica, Piangente, Massa-Barara, Lomashenskaya, Miskhorskaya 3, Coreggiolo, Tavlinskaya, Melkolistnaya, Poroslevaya 3, Ascolano, Manzanillo, Ispanskaya, Tiflis, ets.
Late, ripening in December
Razzo, Leccino

Table 4. Grouping of olive cultivars according to the fruit use.

Fruit use	Cultivars
Canning varieties	Santa Caterina, Sevillano, Tolgomskaya, Tossiyskaya and others
Universal varieties	Dalmatica, Pikvales, Nikitskaya Krupnoplodnaya, Nikitskaya 6, Nadzhviyskaya, Gorvala, and others
Oil varieties	Tiflis, Coreggiolo, Razzo, Della Madonna, Nikitskaya, Krymskaya, others

Table 5. The most promising cultivars -sources of economically valuable characteristics.

Characteristic	Cultivars
Large-fruited	Ascolano, Nikitskaya Krupnoplodnaya, Krymskaya Prevoskhodnaya, Kolkhoznitsa, Konservnaya, Rannyaya, Nokolina, Krymskaya Zvezda, Appetitnaya, Bakinskaya 51, Izyaschnaya, Stolovaya, Universalnaya, Urozhaynaya, Fioletovaya, Otur, Sevillano
High content of oil in fruits	Kolkhoznitsa, Nikolina, Razzo, Dalmatica, Coreggiolo, Krymskaya Rannyaya, Chernaya Rannyaya, Nikitskaya, Konservnaya, Skorospelaya, Manita, Nikolina, Krymskaya Zvezda, Appetitnaya, Bakinskaya 8, Primorskaya, Progress, Stolovaya, Potomok, Universalnaya, Yubileynaya, Della Madonna, Otur
High productivity	Coreggiolo, Tiflis, Nikitskaya Krupnoplodnaya, Kolkhoznitsa, Manita, Krymskaya Prevoskhodnaya
Frost resistance	Tiflis, Nikitskaya Krupnoplodnaya, Nikitskaya, Krymskaya Prevoskhodnaya

Fig belongs to the mulberry family (Moraceae Link), the genus *Ficus* L., the species *caricum* (*Ficus carica* L.). The genus has more than 800 species. Most of the species are tropical plants, but some species can grow and bear fruit in the subtropical zone [15; 16; 17]. Figs are widespread on the southern coast of the Crimea. This is a valuable and highly profitable subtropical fruit crop, consumed both fresh in the area of cultivation, and in the form of processed products (jams, jams, marshmallows, etc.).

One of the first collections appeared in Nikita Botanical Gardens was a collection of fig cultivars. During the first years local cultivars and forms growing on the peninsula were collected, but since 1824 cultivars from Germany, France and Austria began to be introduced. But all cultivars, introduced before 1901, have not survived by 1925.

In 1925, work was resumed on the formation of collections plantations of figs. From 1925 up to 1940 N. Arendt imported cultivars and forms of figs from foreign countries, and

also attracted cultivars of local selection from the Caucasus and Central Asia. At the same time, along with the introduction, a large selection work was carried out.

The first intervarietal crosses of figs were carried out by N. Arendt in the Nikita Botanical Gardens in 1927-1928. The best foreign cultivars of figs were selected for hybridization: Kadota, Cherny Pozdny, Kalimirna. The main direction in the figs selection based on a unique gene collection, was to obtain early ripening cultivars resistant to abiotic factors, with high quality fruits, suitable to various uses. Various methods were used in breeding work: distant and intraspecific hybridization, induced mutagenesis and apomixis.

At present, the fig gene collection in the Nikita Botanical Gardens is represented by the following species: *F. carica* L., *F. afghanistanica* Warb., *F. virgata* Roxb., *F. palmata* Forsk., *F. pseudo-carica* Miq. and has 267 cultivars and forms. The best cultivars of figs are obtained from Georgia, France, Albania, Italy, USA, Tunisia.

Table 6 shows 11 cultivars and forms of figs bred in the Nikita Botanical Gardens, promising for use in the breeding process and introduction into production.

Table 6. Prospective cultivars and forms of figs of NGB selection.

Cultivars	Ripening period	Characteristic				
		Fruit size	Skin color	Economic purpose	Sugar content, %	Taste
Bely Ranny	1dec./IX	middle	green	table	18,3	good
Zheltoplodny Urozhayny	2dec./VIII	middle	yellow	canned	19,0	good
Kadota Zolotistaya	1dec./IX	large	yellow	dry, table	20,6	good
Konsrny Nikitsky	1dec./IX	middle	blue	canned, dry	21,9	excellent
Limonno-zhelty	2dec./IX	large	green	dry	19,3	excellent
Nairayneyshy fioletovy	2dec./VIII	middle	violet	table	15,6	good
Podarok Oktyabryu	1dec./IX	large	green	dry	19,3	excellent
Sabrutsiya rozovaya	1dec./IX	large	pink	table	15,1	excellent
Smena	1dec./IX	large	yellow	dry	22,2	excellent
Sukhofruktovy Nikitsky	2dec./IX	large	green	dry	20,2	excellent
Yantarny	1dec./IX	large	yellow	dry, table	20,8	good

4 Conclusions

Based on the results of the introduction and breeding work, a significant gene collection of subtropical fruit crops was formed, which includes 120 varieties and elite hybrid forms of persimmon, 123 ziziphus, 229 olives and 267 figs.

The evaluation of the gene collections made it possible to identify cultivars-sources of economically valuable characteristics, which were later used in breeding work. On the basis of this gene collection, the best breeding cultivars of the Nikita Botanical Gardens have been obtained: persimmon cultivars: Stella, Zolotistaya, Zvezdochka, Mechta, Nikitskaya Bordovaya, Yuzhnaya Krasavitsa, Suvenir Oseny, Ukrainka and Rossiyanika, etc., ziziphus cultivars - Koktebel, Meteor, Tavrika, Yalita, Sinit, Radoslav, Konfetny, etc., cultivars of olives: Manita, Skorospelaya, Violetta, Nikitskaya, Krymskaya Prevoskhodnaya, etc., cultivars of figs: Yantarny, Sukhofruktovy Nikitsky, Podarok Oktyabryu, Sabrutsia Rozovaya, etc.

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