Genetic Resources of Temperate and Subtropical Fruit and Nut Species at the Nikita Botanical Gardens

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The Nikita Botanical Gardens (NBG), established in 1812, is the oldest botanical garden in the former Soviet Union. The NBG belongs to the Ukraine Academy of Agrarian Sciences and acts as a comprehensive scientific research institute, botanical garden, and tourist attraction. The core botanical garden is located near Yalta, on the Black Sea coast of the Crimean peninsula (Fig. 1). The NBG also has branch research stations within the Crimean peninsula and in the steppes of the Kherson oblast (oblast is synonymous with province).

The name Nikita comes from the small village settled by Greeks several centuries previously, near which the original plots of land were allotted for the Gardens. The Novorossiysk general governor A. Plessy du Richelieu, great-grandson of Cardinal du Richelieu, proposed establishing the botanical gardens. In 1811, a decree was signed in St. Petersburg and the first plantings were made in September 1812, marking the birth of the NBG. Christian Steven, a prominent young scientist of the time, was invited to fill the position of director at the new Gardens. Since there was a need for guidance in the development of southern horticulture and the need for appropriate planting stock, Steven decided the central aim of the Gardens would be the introduction and development of new plants suitable for growing in southern Russia. Within 12 years, Steven had contacted 40 institutions and private growers, who sent plant material from various parts of Europe. He collected a total of 450 ornamental species along with a large number of temperate and subtropical fruit species. Mr. Steven also founded a herbarium and library.

The scientific activities of the NBG includes studying plant resources of the world, with an emphasis on the introduction, selection, and genetic improvement of disease and pest resistant, high yielding, and high quality cultivars of temperate and subtropical fruit and nut species, ornamental, and essential oil-bearing plants.

There are nine departments in the Gardens: flora and vegetation, dendrology and floriculture, subtropical fruit culture, essential oil-bearing and medicinal plants, agroecology, and plant protection, reproductive biology and physiology of plants, biotechnology and biochemistry, plant management, and marketing.

Table 1. Number of accessions of temperate and subtropical fruit and nut species held in collections at the Nikita Botanical Gardens.

| Species         | Total |
|-----------------|-------|
| Almond          | 1,103 |
| Apple           | 760   |
| Apricot         | 783   |
| Cherry          | 541   |
| Cherry plum     | 220   |
| Chinese date    | 140   |
| Feijoa (pineapple guava) | 400 |
| Fig             | 334   |
| Hardy kiwifruit | 11    |
| Hazelnut        | 55    |
| Lemon           | 10    |
| Olive           | 230   |
| Pawpaw          | 16    |
| Peach and nectarine | 1,284 |
| Pear            | 351   |
| Persimmon       | 190   |
| Plum            | 493   |
| Pomegranate     | 370   |
| Quince          | 219   |
| Walnut          | 175   |

The collection of temperate and subtropical fruit and nut species holds 7,685 accessions made up of cultivars, selections, and unique forms (Table 1). The collections include peach and nectarine (Prunus persica (L.) Batsch.), apricot (Prunus armeniaca L.), European plum (Prunus domestica L.), cherry-plum (Prunus cerasifera Ehrh.), sour cherry (Prunus cerasus Ehrh.), apple (Malus xdomestica Borkh.), pear (Pyrus communis L.), quince (Cydonia oblonga Mill.), almond (Prunus dulcis (Mill.) D. A. Webb.), walnut (Juglans regia L.), hazelnut (Corylus avellana L.), pomegranate (Punica granatum L.), fig (Ficus carica L.), persimmon (Diospyros spp.), Chinese date (Ziziphus jujuba Mill.), hardy kiwifruit (Actinidia spp.), pawpaw (Asimina triloba (L.) Dunal), lemon (Citrus limon (L.) Burm.), and feijoa or pineapple guava (Feijoa sellowiana Berg.).

There is also a prominent small family of temperate and subtropical fruit and nut species: fl ora and vegetation, dendrology and floriculture, subtropical fruit culture, essential oil-bearing and medicinal plants, agroecology, and plant protection, reproductive biology and physiology of plants, biotechnology and biochemistry, plant management, and marketing.

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ing. The research staff today consists of 187 workers, including 75 PhD scientists, 2 post-doctoral scientists, and 47 graduate students. The gardens have 5 industrial and experimental branches: Central (in Yalta), Primorskie (16 km east of Yalta), Stepnoe (12 km north of Simferopol), Novokakhovskoe (2 km south of Novaya Kakhovka, Kherson oblast), and the Dzhankoy introduction quarantine facility (6 km north of Dzhankoy) (Fig. 1). The total area occupied by the NBG, including all of its branch stations, is 1,835 ha.

Accessions are evaluated for adaptation to a range of climatic conditions, since the collections and research stations are located in two very different climatic zones. This includes the south coast of Crimea where sub-tropical plants grow and the steppe region where air temperature can drop to ~30 °C. Mountain ranges stretch across southern Crimea creating a narrow band (about 2 km wide by 200 km long) of Mediterranean climate along the south coast (although microclimates vary considerably depending on elevation, exposure, and degree of slope). A transition to a more continental climate quickly occurs as you move north and away from the coastline.

**Breeding Activities at the NGB**

*Peach and nectarine.* The first peach breeder at the NBG was Ivan N. Ryabov (1923–1984). He devoted over half his life to peach culture, breeding, and classification. Ryabov made many trips to Central Asia and the Trans-Caucasus to collect and study the diverse peach germplasm found there. His collections became the base of the NBG peach genetic improvement program, yielding dozens of new cultivars used in commercial orchards of the southern regions of the former Soviet Union (Andriyenko, 1997).

In 1978, Vladimir K. Smykov became director of the NBG fruit breeding program. Previously he worked for >20 years at the Moldavian Institute of Horticulture, Viticulture, and Wine Production. During his work in Moldova, Smykov established large collections of apple, peach, apricot, and pear germplasm that resulted in the release of >50 new cultivars. Much of this material was brought to the NBG with his arrival. Smykov subsequently utilized many horticultural techniques including radiation mutation breeding, interspecific hybridization, and isozyme analysis (Smykov and Lischuk, 1999).

Vladimir K. Smykov, Anatoly V. Smykov, and Tatyana A. Latsko currently carry out the breeding and study of peach at the NBG. The main peach research is at the Central branch of the NBG, with additional testing and improvement at the Stepnoe branch. Over a period of 20 years, 30 new cultivars were developed at the NBG, 3 of which are planted commercially in the steppe region of Ukraine. Additional selections are currently undergoing evaluation in state and industrial cultivar trials. Early ripening, yellow-fleshed cultivars of peach were obtained and used in the breeding program (Table 2), as were small-sized tree forms. In addition, Smykov has worked out a complex method of selection for peach (Smykov and Lischuk, 1999).

Peach cultivars developed at the NBG typically flower during the last week of April and ripen over an extended period between the first weeks of July to the third week of September. The earliest maturing cultivar in the collection is ‘Favorita Morettini’, ‘Granatovy’ and ‘Yubileyny Ranny’ ripen 2 to 3 d later, have larger, more attractive fruit with a higher percent overcolor, and are very flavorful (Table 2). ‘Pontiysky’ and ‘Demerdzhinsky’ ripen one week later than ‘Favorita Morettini’, and have large, brightly colored fruit. ‘Demerdzhinsky’ also has cold Hardy flower buds and is more frost resistant than many of the other cultivars. ‘Krymsky Feyerverk’ has shown good commercial performance, with a very high fruiting potential, and a tree form that rarely needs pruning. It endures the Crimean winters very well, and has attractive, very flavorful fruit. ‘Sagdiets’ has shown a high level of resistance to frost and powdery mildew [Podosphaera leucotricha (Ell. et Ev.) Salmon], while also having very large and fla-vorous fruit. ‘Startovy’ has shown outstanding commercial performance with consistent fruit set in the contrasting temperature conditions of the different climatic zones of Crimea. It has large flavorful fruit with firm flesh. ‘Dostoyni’ is of great interest due to its attractive fruit that has shown good transportability. It is also the only cultivar from the NBG used for canning. The remaining cultivars (Table 2) are mainly eaten fresh, made into jam, or dried. ‘Olichnik’ is characterized by the development of plentiful flower buds. ‘Posol Mira’ has shown outstandingly high yields, high resistance to cold and a high degree of seedlessness.

**Table 2. Characteristics of peach cultivars released by the Nikita Botanical Gardens from 1994 to 2004.**

| Cultivar                | Fruit wt (g) | Ground color     | Overcolor (%) | Year to fruiting | Ripening date | Yield capacity (kg/tree) |
|------------------------|--------------|------------------|---------------|------------------|---------------|-------------------------|
| Favorita Morettini†    | 100          | Bright yellow    | 60            | 2–3              | 7 July        | 25–30                   |
| Granatovy              | 120          | Yellow           | 75–100        | 2–3              | 9 July        | 25–30                   |
| Yubileyny Ranny        | 120–140      | Yellow           | 80–100        | 3                | 10 July       | 75–80                   |
| Lakomy                 | 130          | Yellow           | 75–100        | 2–3              | 11 July       | 23–25                   |
| Pamynty                | 110–130      | White-yellow     | 80–100        | 2–3              | 12 July       | 25–28                   |
| Podarok Neveste        | 95–120       | Yellow           | 50–75         | 3–4              | 13 July       | 30–35                   |
| Pontiysky              | 120          | Yellow           | 75–100        | 3–4              | 14 July       | 25–30                   |
| Demerdzhinsky          | 140          | Orange           | 80–100        | 3                | 15 July       | 28                      |
| Krymsky Feyerverk      | 110–120      | Yellow           | 75–100        | 3–4              | 17 July       | 45–55                   |
| Lyubimy                | 140          | Yellow           | 75–100        | 3–4              | 18 July       | 24–30                   |
| Ukrainets              | 130          | Yellow           | 60            | 3–4              | 19 July       | 30–35                   |
| Sagdiets               | 160–180      | Yellow           | 30–50         | 2–3              | 21 July       | 35–40                   |
| Pushasty Ranny‡         | 110–120      | Green-cream      | 50–75         | 3                | 22 July       | 35–40                   |
| Startivy               | 140–150      | Yellow           | 50–60         | 2–3              | 23 July       | 25–30                   |
| Metcha                 | 150          | Yellow           | 50–75         | 2–4              | 24 July       | 25–28                   |
| Orekhovy               | 150          | Yellow           | 30–50         | 2–3              | 25 July       | 26–29                   |
| Temusovskiy            | 150          | Yellow           | 75–100        | 2–3              | 26 July       | 32–35                   |
| Dostoyni               | 135          | Yellow           | 50–75         | 2–3              | 26 July       | 27–33                   |
| Kandidatsky            | 120          | Yellow           | 50–75         | 2–3              | 27 July       | 29–32                   |
| Naryadny Nikitsky      | 150          | Yellow           | 75–100        | 2–3              | 28 July       | 26–30                   |
| Vasilivsky             | 150          | Yellow           | 50–75         | 3–4              | 29 July       | 40–45                   |
| Olichnik               | 150–170      | Yellow           | 40–50         | 2–3              | 30 July       | 40–48                   |
| Nikitsky Podarok       | 130          | Yellow           | 75–100        | 3–4              | 31 July       | 25–30                   |
| Garmoniya              | 130–140      | Yellow           | 75–100        | 2–3              | 1 Aug.        | 25–28                   |
| Doktorsky              | 120          | Yellow           | 50–75         | 3–4              | 2 Aug.        | 24–27                   |
| Posol Mira             | 160          | Yellow           | 50–75         | 3–4              | 3 Aug.        | 25–30                   |
| Red Haven†             | 137          | Orange           | 75–100        | 4                | 4 Aug.        | 40–45                   |
| Sochnyi                | 124          | Green-cream      | 30–50         | 3–4              | 6 Aug.        | 50–60                   |
| Rumyanny Nikitsky      | 130          | Yellow           | 75–100        | 2–3              | 8 Aug.        | 26–30                   |
| Osvezhayaschy           | 160–170      | Yellow           | 95–100        | 3–4              | 15 Aug.       | 24–28                   |
| Krimsky Yumat          | 140          | Yellow           | 75–100        | 3–4              | 17 Aug.       | 45                      |
| Kremlevskiy            | 160          | Yellow-orange    | 50–75         | 3–4              | 18 Aug.       | 82                      |

†Check cultivar.
spring frosts, plentiful flower buds, and large (>150 g) attractive fruit with firm flesh. The peach cultivars that ripen in September are 'Muzu' and 'Krymskaya Osen' with yellow flesh and 'Turist' with white flesh. Many years of commercial evaluation have shown these cultivars to be broadly adapted to diverse climatic conditions, along with having superior market quality. The breeding program at the NBG has been successful with selections expressing desirable breeding characteristics, belonging to four different Prunus species. Ornemental peach cultivars differ in flower color, flower form, petal number, crown shape and structure, bloom period, resistance to powdery mildew [Podosphaera leucotricha (Ell. et Ev.) Salmon] and peach leaf curl (Taphrina deformans Jacz.), and have been a success in state cultivar testing. 'Ruteniya', 'Le', and 'Fler Pompon' are very promising and are currently being tested. 'Ruteniya' has purple-pink bell-form flowers. 'Le' is unique for its small half-double flowers that are lilac-pink. 'Fler Pompon' has light purple-pink flowers with 60 to 100 petals. All cultivars mentioned blossom over a 20-day period with a great abundance of flowers and pleasant aromas.

**Table 3. Characteristics of apple cultivars released by the Nikita Botanical Gardens from 1994 to 2004.**

| Cultivar | Fruit wt (g) | Color | Ripening date | Shelf life (until) | Yield (kg/tree) | Growth habit | End use |
|----------|-------------|-------|---------------|-------------------|----------------|--------------|---------|
| Flat | 120 | Yellow with red blush | 20–30 July | August | 16 | Medium size | Fresh, juice |
| Colorist | 150 | Green-yellow | 20–30 July | August | 17 | Medium size | Fresh |
| August | 130 | Yellow with red blush | 1–10 Aug. | November | 16 | Compact | Fresh, juice |
| Naslednitsa Yuga | 140 | Orange-red | 10–20 Aug. | September | 15 | Small | Fresh, juice |
| Vashenyaya Zarya | 170 | Yellow | 1–10 Sept. | November | 20 | Medium size | Fresh, juice |
| Malinovy Delicius | 200 | Yellow with red blush | 1–10 Sept. | November | 18 | Medium size | Fresh, juice |
| Urennyaya Zorka | 180 | Bright crimson | 1–10 Sept. | November | 17 | Medium size | Fresh, juice |
| Kodrskoe | 150 | Red blush | 10–20 Sept. | October | 17 | Small | Fresh |
| Luchalfer | 130 | Yellow with red blush | 10–20 Sept. | October | 16 | Small | Fresh |
| Kalvi Moldavsky | 150 | Orange | 20–30 Sept. | April | 21 | Medium size | Fresh |
| Nov | 200 | Yellow with red blush | 20–30 Sept. | March | 24 | Small | Fresh, juice |
| Pepin Moldavsky | 190 | Green-red | 20–30 Sept. | February | 16 | Small | Fresh |
| Ranet Moldavsky | 150 | Yellow with red blush | 20–30 Sept. | February | 17 | Small | Fresh |
| Aurel | 190 | Yellow with red blush | 20–30 Sept. | March | 16 | Medium size | Canning |
| Buzhor | 150 | Dark crimson | 20–30 Sept. | April | 17 | Small | Fresh |
| Moldavskoe | 140 | Yellow with red blush | 20–30 Sept. | February | 20 | Medium size | Fresh, juice |
| Krasnoye | 160 | Dark red | 20–30 Sept. | March | 19 | Medium size | Fresh |
| Speranta Yarna | 190 | Yellow with red blush | 20–30 Sept. | March | 18 | Medium size | Fresh |
| Vagnera Nyovye | 130 | Yellow with red blush | 20–30 Oct. | May | 25 | Small | Fresh |
| Rumanny Alpinist | 150 | Bright green | 20–30 Oct. | June | 26 | Medium size | Fresh |
perform well under Crimean conditions with 'Rumyannaya Zorka'. Late-ripening cultivar 'Krymskaya Sharovidnaya'. 'Olenka'. 25 to 33 g fruit. The flesh is yellow-cream colored, firm, and aromatic. This cultivar has good transportability, high yield capacity, and consistent fruiting. 'Rumyannaya Zorka'. Late-ripening cultivar with orange-yellow raspberry blush 28 to 60 g fruit. The flesh is bright yellow, firm, and juicy with a sour-sweet taste. This cultivar has great transportability, high yield capacity, and consistent fruiting.

Plum. Klavdiya F. Kostina also paid great attention to plum, Prunus domestica. She developed many valuable cultivars. One named ‘Vengerka Krupnaya’ is still used today for commercial plantations in Ukraine and Moldova. A large number of plum cultivars and selections from Moldova and Yugoslavia were received from Moldova in 1978 with the arrival of Vladimir K. Smykov. Many of them (for example ‘Vengerka Yubileinaya’) have performed well under Crimean conditions.

Sour cherry. Ivan N. Ryabov developed the large sour cherry (Prunus cerasus) improvement program at the NBG. He bred many valuable cultivars and some of them (‘Zarya Vostoka’ and ‘Yantarnaya’) are still used today for commercial plantations in Ukraine. At present, Lyubov A. Lukichova works with cherry culture at the NBG. Recently, early-ripening cultivars with large fruit and high market quality were selected from previous cherry hybrid populations held at the Gardens. The newly selected cultivars ‘Znatnaya’ and ‘Kutuzovka’ are quite remarkable due to their resistance to cracking during wet weather. Hungarian sour cherry cultivars, such as ‘Erdei Botermo’, are the most promising in the sour cherry collection.

Apple. Widely used introduction and breeding program at the NBG. Here are some of the best populations held at the Gardens.

Pomegranate. Nina K. Arendt began working on pomegranate at the NBG in 1946. The collection is currently one of the largest in the former Soviet Union with 370 accessions, and is the only one in Ukraine. This material was collected during expeditions to Central Asia and the Trans-Caucasus and was also introduced from Iran, Afghanistan, Spain, Italy, and the U.S. The main selection criteria are early ripening fruit, high yield, fruit mass of 300 to 350 g, dark color, total sugar content of 14% to 15%, and a juice yield of 60% to 65%. Today, Tatiana V. Litvinova continues the pomegranate program at the Gardens.

Chinese date. In 1953, Liidiya T. Sinko organized collections of chinese date from China, Central Asia, Azerbaijan, Georgia, and Crimea. Presently, the collection holds 140 cultivars and forms with ongoing evaluation and breeding work done by T.V. Litvinova.

Fig. Nina K. Arendt developed the fig program at the NBG. She collected >300 cultivars and forms including native selections and cultivars introduced from Albania, Azerbaijan, Bulgaria, Georgia, Turkey, Tunisia, France, Israel, Italy, U.S., Germany, and Yugoslavia.
Top fig cultivars of the NBG
‘Podarok Oktyabrya’. Light-green skin, dark pink flesh, and average fruit weight of 60 to 70 g. Dried fruit type that requires cross-pollination.

‘Nichkovskii’. Dark-blue skin, carmine-red flesh, and average fruit weight of 40 to 50 g. Canned fruit type that requires cross-pollination.

‘Smena’. Yellow skin, pink flesh, and average fruit weight of 60 to 65 g. Dried fruit type that requires cross-pollination. This cultivar resulted from interspecific hybridization between ‘Kadota’ and Broussonetia papyrifera L. pollen.

‘Zhelttoplodny Urozhainy’. Light-yellow skin, pink flesh, and average fruit weight of 60 to 65 g. Suitable for drying and canning, and requires cross-pollination. This cultivar resulted from mutation breeding work with ‘Smena’.

‘Subbatsiya Rosovaya’. Brown-red skin, pink flesh, and average fruit weight of 90 g. Table type that requires cross-pollination. This cultivar was selected from apomictic seedlings of ‘Sara Lob’.

Persimmon. There are four species of persimmon held in the NBG collection: Diospyros kaki L., D. lotus L., D. virginiana L., and D. sinensis L. The last three species have small fruit and are usually used as rootstocks for D. kaki (Arendt and Rikhter, 1960). The germplasm collection created by Nina K. Arendt and Arkadiy K. Pasenkov numbers 190 cultivars and unique forms of native and foreign origin, including 40 introduced from China and Japan. Two cultivars ‘Rossiyanka’ and ‘Nikitskaya Bordovaya’ developed at the Gardens have high frost tolerance. They have endured temperatures of ~24 °C without damage. The fruit of ‘Rossiyanka’ and ‘Nikitskaya Bordovaya’ have masses of 100 and 130 g, respectively. Both cultivars are of the astringent type. Today, Alexander N. Kazas continues the work with persimmon.

Top persimmon cultivars of the NBG
‘Sputnik’. A productive, monoeccious, nonastringent type with 100 g fruit that has been regionalized on the south Crimean coast.

‘Mechta’. A high-yielding, monoeccious, astringent type with red-orange fruit of up to 200 g. ‘Ukrainka’. An early-ripening, monoeccious, non-astringent type with 100 g fruit. Coloring of fruit begins in early September.

Olive. The first olive trees were planted at the NBG in 1822. Nina K. Arendt began breeding and evaluation work in 1927. Violetta A. Sholokhova continued this program in 1960. Currently, there are 228 cultivars and selections in the collection, including 126 foreign cultivars and 102 cultivars developed at the NBG. The main breeding objectives are precocity, early ripening and maturing, high oil content, cold hardness, and high productivity. Today, Lidiya F. Myazina continues the olive program at the Gardens.

Top NBG olive cultivars
‘Krymskaya Prvoskhodnaya’. Early ripening, large size (6.7 g) fruit with soft, aromatic flesh. The yield capacity is 4 t·ha⁻¹, the oil yield is 18% to 21%, and it has universal use.

‘Nikitskaya Krupnoplodnaya’. Large size (5.0 g) fruit with firm, oily flesh. The yield capacity is up to 6 t·ha⁻¹, the oil yield is 31%, and it has universal use.

‘Nikitskaya’. Medium size (3.0 g) fruit with firm, oily flesh. The yield capacity is up to 6 t·ha⁻¹, the oil yield is 36%, and it has universal use.

‘Feijoa’. The collection of Feijoa sellowiana Berg., also known as pineapple guava, at the NBG contains 400 accessions. The most promising selections have high consistent yields, high winter-resistance, are early ripening, and have fruit masses of 20 to 35 g. E.L. Shishkina currently conducts the Feijoa research.

Pawpaw. The collection of pawpaw (Asimina triloba) contains 16 foreign cultivars and >80 seedlings. The collection was planted in 1997 and it is the only one in Ukraine. Currently, selection of the best forms from open pollinated seed progeny has been done, with eight promising seedlings beginning to produce fruit. Khokhlov works on the introduction, breeding, and evaluation of pawpaw.

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Conclusions
In addition to being a beautiful botanical garden and tourist attraction set on the stunning southern coast of the Crimean peninsula, the Nikita Botanical Gardens contain one of the oldest and most diverse collections of temperate and subtropical fruit and nuts in Europe. The vast germplasm repository collected and maintained by the NBG for nearly 200 years represents a valuable resource for fruit and nut breeders worldwide. Cultivars and collections developed by outstanding breeders such as Kostina, Ryabov, and others at the Gardens established the foundation for fruit culture and industry in many parts of the former Soviet Union. Their work and the work of current scientists at the Gardens represent a tremendous body of knowledge and plant genetic resources that have yet to be fully utilized by breeders in the western world. This paper highlights these assets. The NBG looks forward to collaboration, cooperation, and the sharing of plant germplasm with interested scientists around the world.

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