Conservation of biodiversity of subtropical crops (*Citrus* L., *Diospyros kaki* L., and *Feijoa sellowiana* B.) in the collections of the Federal Research Center SSC of RAS

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Abstract. The article examines the biodiversity of subtropical plants in the collections of the Subtropical Scientific Center of the Russian Academy of Sciences (*Citrus* L., *Diospyros kaki* L. and *Feijoa sellowiana* B.). Citrus fruits are represented by 144 taxa, persimmon – 27 varieties, feijoa – 13 specimens. The purpose of the study is to preserve biodiversity and replenish collections with new introduction and selection varieties. Collectible specimens are preserved alive and serve as the object of comprehensive research. Sources of economically valuable traits - early ripening, dwarfism, winter hardiness, early ripening, fruit size and productivity - have been identified and included in various breeding programs for the creation and improvement of varieties. As a result of hybridization, a diverse range of hybrid forms was obtained, including 350 forms. Two forms of *Feijoa sellowiana* (SHW-1: 13-11), two hybrids of *C. paradise* (GA-1; G-A-2) and four forms of *Diospyros kaki* are currently being tested. In 2023, the biodiversity of the collections was replenished with four new varieties bred at the Center. Three varieties of tangerine ('Academichesky', 'Solnechny', 'Prince Vladimir') and a variety of eastern persimmon ('Zukhra') are included in the State Register of Breeding Achievements of the Russian Federation.

1 Introduction

Plants are an integral component of biological diversity and a crucial resource for human well-being. Cultivated plants hold significant economic value by providing sustenance for humanity. The preservation of plant genetic resources (species, varieties, hybrids) essential for agriculture is greatly influenced by bioresource collections for medium- to long-term storage (in situ and ex situ, botanical gardens, seed banks, and in vitro collections) [1-7].

Conservation methods are continually evolving, with significant attention directed towards the establishment of germplasm banks, cryopreservation, and biotechnological approaches [8-9]. In addition to preservation efforts, collections are consistently augmented through introduction and breeding activities [10-11]. Utilizing methods such as distant

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hybridization, mutagenesis, polyploidy, and nucellar polyembryony has resulted in a diverse array of citrus, persimmon, feijoa, and other subtropical crops [12-14]. The generated material exhibits a high level of agro-biological traits and holds significant value for breeding new varieties.

The constant enrichment of collections through introduction and breeding efforts is integral to the maintenance of genetic diversity. Notably, the use of distant hybridization, mutagenesis, polyploidy, and nucellar polyembryony methods has led to the creation of a wide variety of citrus, persimmon, feijoa, and other subtropical crop forms [10]. The generated material possesses a high level of agro-biological characteristics and is highly valuable for the development of new varieties.

2 Materials and methods

Currently, a significant biodiversity plants, including 144 taxa of citrus, 27 taxa of East Asian persimmon, and 13 samples of feijoa (Figure 1), characterize the collection of subtropical crops.

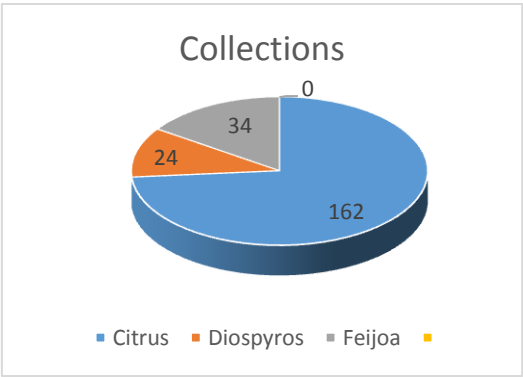

Fig. 1. Collection varieties.

The collection comprises unique citrus cultivars that exhibit winter hardiness, including C. ichangensis, C. japonica, C. trifoliata, C. unshiu 'Chernomorskiy,' C. unshiu hybrid 3252, Citrangequat (C. sinensis × C. trifoliata × C. japonica), and C. × insitorum. The collection also preserves variegated specimens, including C. microcarpa variegata, C. medica variegata, and C. australasica 'Red Champagne' variegate.

For persimmons, three species are represented: Diospyros lotus L., Diospyros virginiana L., and Diospyros kaki L. The economic importance of Diospyros kaki for fruit production is emphasized in the collection, which houses varieties with different ripening periods. Notably, there is a group of varieties with astringent fruits, such as 'Djiro', 'XX Century', 'Fuyu', and 'Geili'. Varieties with enhanced winter hardiness, such as 'Djiro,' 'Hiakume,' 'MVG Omarova', and those with high drought resistance, such as 'Seedles' and 'Hostinsky', have been identified. The collection includes highly adaptable varieties for the humid subtropics of Russia, such as 'Hiakume', 'Hachia', 'Zenji-Maru', Djiro', 'Seedles', 'Nikitskaya bordovaya', 'Roman Kosh', 'Gora Hoverla', 'Gora Rogers', and 'Novinka'. A group of high-yielding varieties, producing between 80 to 100 tons/ha, includes 'Hiakume', 'Seedles', 'Djiro', 'Hachia', 'Tamopan big', and 'Hostinsky'.

In recent years, there has been significant expansion of feijoa plantations in subtropical regions of Russia, leading to an increased demand for cultivars. The Feijoa sellowiana Berg collection includes both varieties and promising forms identified in industrial plantations. A group of early-ripening forms has been established, such as 'Sentyabrskaya', 8-10, 4-10,

12-5, SHW-1, and 13-11. Varieties 'Dagomysskaya', 'Sentyabrskaya', 'Dachnaya', 'Superba', and forms 8-10, SHW-1, 13-11, characterized by high yields of 110-120 tons/ha, are particularly valuable for production.

The research utilized methodologies from the State Variety Testing of Agricultural Crops, as well as programs and methodologies for testing fruit, berry, and nut crops. Comprehensive phenotypic evaluations were conducted according to UPOV protocol.

The primary objective of the work is to preserve and replenish the collection, analyze biodiversity, and identify sources of economically valuable traits for inclusion in breeding programs aimed at developing new resilient varieties. The success in creating new genotypes depends largely on the availability of diverse sources of economically valuable traits that can be passed on to the offspring.

3 Results

As a result of studying the collection, sources of economically valuable traits have been identified, and these were utilized in various breeding combinations to obtain hybrid forms (Table 1).

Table 1. Sources of Economically Valuable Traits.

Trait	Species, Variety, Hybrid
Citrus	
Early fruiting (2-3 years)	Citrus reticulate var. unshiu cultivars – 'Izeki Wase', 'Kowano-Wase', 'Miyagawa Wase', 'Ochi Wase', 'Ikeda', 'Millennium 1', 'Sentyabrskiy', 'Yubileyniy', 'Slava Vavilovu', C. × leiocarpa 'Shiva-Mikan', C. × meyeri, C. × microcarpa, C. × limonelloides.
Dwarf stature (up to 2.5 m)	Citrus reticulata var. unshiu – 'Izeki Wase', 'Kowano-Wase', 'Miyagawa Wase', 'Ochi Wase', 'Ikeda',' Solnechny' (Sunny), C. × leiocarpa 'Shiva-Mikan', C. × microcarpa, C. × limonelloides, C. limon – 'Dioskouria', C. aurantiifolia 'Taiti', C. × meyeri
Winter hardiness (up to -5°C)	Citrus reticulata var. unshiu – Hybrid 3252, Hybrid 10, 'Chernomorskiy', 'Sochinskiy 23', 'Pioneer 80', 'Unshiu Shirokolistny', 'Georgievskiy', 'Iveriya', C. × clementina 'Kikli', C. maxima 'Natsu mikan', Fortunella margarita – Hybrids 78, 202 C. limon – 'Dioskouria', 'Odishi', C. × meyeri.
Cold resistance (up to -15°C)	Poncirus trifoliata, C. ichangensis, C. × junos juzu, C.× insitorum, Citrangequat (C. sinensis × P. trifoliata) × Fortunella)
Early ripening (III decade of September - I decade of October)	Citrus reticulata var. unshiu – 'Izeki Wase', 'Kowano-Wase', 'Miyagawa Wase', 'Ochi Wase', 'Ikeda', 'Sentyabrskiy', 'Yubileyniy', 'Solnechny', 'Slava Vavilovu', 'Millennium 1', C. limon – 'Lunario', C. × limonelloides C. × microcarpa, C. aurantiifolia 'Foro', C. × meyeri
Diospyros	
Dwarf stature (up to 2.5 m)	'МВГ Omarova', 'Fuyu', 'Geili'
Winter hardiness (up to -15°C)	'MVG Omarova', 'Seedles', 'Djiro', 'Hiakume'
Cold resistance (up to -20°C)	Diospyros lotus L., Diospyros virginiana L., 'Mieder'
Early ripening (III decade of September - I decade of October)	'Geili', 'Djiro', 'Seedles', 'Geili', 'Zenji-Maru', Diospyros lotus L
Astringency	'Geili', 'Djiro', 'Fuyu'
Large fruit size (fruit weight - 180g)	'Djiro', 'Hiakume', 'Hachia', 'Tamopan big'
Feijoa	
Early ripening (II-III decade of September - I decade of October)	'Sentyabrskaya', 'Dachnaya', 8-10, 4-10, 12-5, SHW-1, 13-11
Fruit quality (sum of sugars 6.0 and above)	'Dachnaya', 'Dagomysskaya', 'Superba'
Small fruit size (fruit weight - 40-50g)	'Dachnaya', 'Dagomysskaya', 4-10, 12-5, SHW-1, 13-11

Hybridization was conducted based on the collection using the identified sources of economically valuable traits as one of the parents. As a result of distant and intervarietal hybridization, 350 hybrid forms of citrus, 78 forms of East Asian persimmon, and 46 promising forms of feijoa were developed. These hybrids possess economic and valuable traits and are of significant importance for the creation of new varieties (Figure 2).

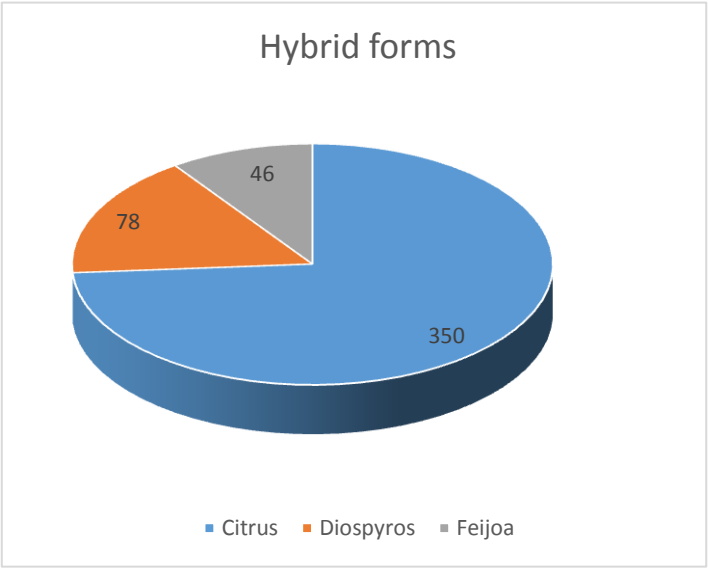

Fig. 2. Hybrid forms.

The breeding program for creating winter-hardy, early-ripening, and high-yielding varieties of Citrus is based on the utilization of distant hybridization, mutational variability, and selection at the nucellar level. A total of 350 genotypes were identified, including 60 promising and 28 elite specimens. Through selection, three new varieties of *C. reticulate* var. *unshiu* were developed: 'Solnechny', 'Akademicheskiy', and 'Knyaz Vladimir'. Promising hybrids were also identified: *C. paradise* GA-1, GA-2, *C.* × *bergamia* (Bergamot 16), and C. limon 2-11.

The hybrid collection of *Diospyros* comprises 78 specimens, including 20 promising and 10 elite samples obtained through inter-species and inter-varietal crossings. As a result of research, a new *Diospyros kaki* L. variety called 'Zuhra' was bred, along with several hybrids undergoing production trials (No. 1-25: 'Hiakume' × 'Miader', No. 1-27: 'Seedles'× pollen mixture ('Geili', 'Fuyu', 'Zenji-Maru'), No. I-15 ('Zenji-Maru' × pollen mixture ('Geili', 'Fuyu', 'Zenji-Maru'), No. 23: 'Hachi'' × 'Geili').

To expand the assortment and develop new *Feijoa sellowiana* Berg varieties, 8 inter-varietal crossbreeding combinations were conducted, resulting in a large hybrid pool adapted to the humid subtropics of Russia. The best crossbreeding combinations were identified, leading to 46 hybrids, including 10 elite ones with high and stable productivity. The most promising ones, such as 12-5, 4-10, SHI-1, 13-11, 10-22, and B-13, exhibit vigorous growth and, in terms of fruit weight and yield, are comparable to the regionally adapted variety 'Superba'.

4 Conclusion

Extensive collections of citrus fruits, persimmons and fajitas are collected at the Federal Research Center "Center for Subtropical Research" of the Russian Academy of Sciences. These collections preserve both cultivated varieties and their wild relatives in living form. These collections make it possible to preserve and increase biodiversity. A comprehensive study of collections makes it possible to identify genetic sources and, on their basis, carry out hybridization, obtain numerous hybrids and, on their basis, develop new varieties that are most adapted to the climatic conditions of the subtropical zone of the Krasnodar Territory.

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