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The Schroeder Institute in Uzbekistan: Breeding and Germplasm Collections

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Central Asia was largely isolated from the western world from the early 1800s until 1991, when the former Soviet Union was dissolved. During this time, many research institutions were established to work on economically important crop species and to amass large and unique germplasm collections, including the Uzbek Scientific Research Institute of Plant Industry (former branch of VIR) and Uzbek Scientific Research Institute of Cotton Breeding and Seed Production.

The Turkestan Agricultural Experiment Station (TAES) was established in 1898 in Tashkent Province, Republic of Uzbekistan (Fig. 1). Academician Richard R. Schroeder (Fig. 2) served as the director of TAES from 1902 to 1944. Initially, TAES focused on tree fruits; grapes (*Vitis vinifera* L.); various vegetables; fiber crops, such as cotton (*Gossypium hirsutum* L. and *G. barbadense* L.), kenaf (*Hibiscus cannabinus* L.), and hemp; (*Cannabis sativa* L.), rice (*Oryza sativa* L.), cereal crops, and forage crops. Later, separate research institutes were established to focus on individual crops and initiate specific breeding programs. TAES was the first institute in Central Asia established for studies of genetics/breeding and the cultural management of fruits, grapes, and nuts.

Schroeder developed improved cultivars of cotton, rice, corn (*Zea mays* L.), and other crops (Schroeder, 1956). In tree fruits, he focused on improving cold-hardiness, resistance to diseases and insects, and yield. In 1911, Schroeder participated in the 7th International Congress of Arid Lands in the United States for cotton and orchard crops. While in the United States, he collected seeds of legumes, sorghum, and cotton cultivars and evaluated them in Central Asia. Shortly thereafter, Schroeder published an agricultural monograph that was widely distributed throughout the Russian Empire and, later, the USSR (Schroeder, 1913).

Following Richard Schroeder's death in 1944, his son, Alexander R. Schroeder, continued the apple (*Malus ×domestica* Borkh.) breeding program, developing and releasing cultivars that are still popular in Central Asia: 'Renet Tashkentsky', 'Borovinka Tashkentskay', 'Tilly alma', 'Letnee polosatoe', 'Iskander', 'Ubileinoe Shredera', 'Navoi', 'Dastarhoni', 'Argus', 'Kalvil Tashkentsky', and 'Zimnee Shredera'. Later, Schroeder's granddaughter, Elena Schroeder, joined the

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Fig. 1. Map of the Republic of Uzbekistan (reproduced with permission from the Dept. of Public Information, Cartographic Section, United Nations, Map No. 3777 Rev. 3, Aug. 1998).

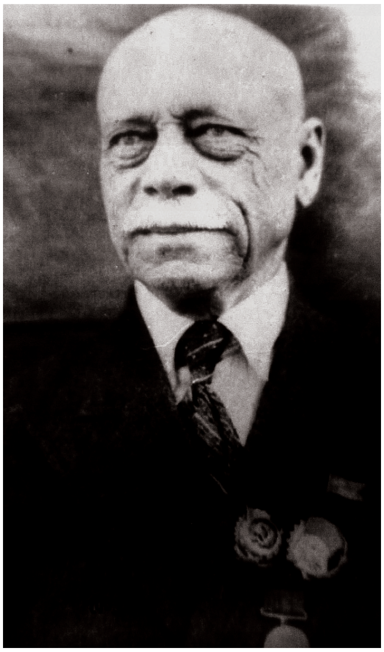


Fig. 2. Academician Richard R. Schroeder served as director of the Institute from 1902 to 1944.

Fig. 3. Academician Mahmud M. Mirzaev served as director of the Institute from 1949 to 2000.

apple breeding program, and presently continues this work.

TAES was named after Richard Schroeder in 1929. At this time, the scientific program was expanded and awarded greater financial support by the federal government. In 1947 the organization was renamed the Richard R. Schroeder Uzbek Research Institute of Fruit Growing, Viticulture, and Wine Production (referred to hereinafter as the Schroeder Institute).

Mahmud M. Mirzaev (Fig. 3) was appointed director of the Schroeder Institute in 1949 and served in this role for 51 years until his death in Aug. 2000. He focused on the interspecific hybridization of orchard species and development of improved grape cultivars. Mirzaev published over 300 scientific articles, books, and monographs, including *Apricots in Uzbekistan* (Mirzaev and Kkuznecov, 1984), *Ampelography of Uzbekistan* (Mirzaev et al., 1984), *Pomology of Uzbekistan* (Mirzaev et al., 1983), *Orchards of the Foothills and Mountain Zone of Uzbekistan* (Mirzaev, 1982), and *Vineyards of the Foothills and Mountain Zone of Uzbekistan* (Mirzaev, 1980). In recognition of his voluminous contributions, Mirzaev was elected to both the Uzbek and Russian Academies of Science. His son, Mirmahsud M. Mirzaev, replaced him as Institute director.

From 1956 to 1957, branches of the Schroeder Institute were established in geographical areas of Uzbekistan having different soil types and climatic conditions. The Schroeder Institute currently has five major satellite facilities: a branch in Samarqand Province devoted to orchard and vineyard crops, a branch in Farghona Province devoted to orchard and vineyard crops in mountainous regions, the South Uzbekistan Experiment Station in Surkhondaryo Province, and two branches in Tashkent Province, one specializing in wine production and the other in orchard crops. There are also three minor satellite branches: Namangansky (Namangan Province), Sokhsky (Andijon Province), Bukharsky (Bukhara Province), and 17 experimental farms (Fig. 1). In total, the Schroeder Institute oversees 11,000 ha of research farms.

The Institute also developed an educational program where students could earn associate degrees in orchard crops. In the late 1960s, the Schroeder Institute created a Bureau of Agricultural Machinery to develop or adapt farm equipment for use in orchards. In addition, the Institute developed new cultivars of fruit, nut, citrus, and grapes, and developed cultural and processing technology, including the canning, packaging, and bottling of fruit juices, wines, champagnes, vodkas, and cognac. The Institute currently operates a full-scale wine production plant with adequate storage facilities for aging studies. Furthermore, the Schroeder Institute established an agribusiness college in 1995.

The main Schroeder Institute in Tashkent Province includes 22 laboratories and greenhouses that are used for research in plant breeding, cultural management, mechanization, and physiology and biochemistry of crops. About 300 faculty and technicians are employed at the main facility. The Institute maintains an extensive and unique field gene bank of more than 2000 advanced accessions of apples and pears, about 1300 grapes, 260 citrus, 500 apricots (*Prunus armeniaca* L.), 270 peaches (*Prunus persica* L. Batsch.), 65 plums (*Prunus domestica* L.), 125 brambles, and 150 nuts {walnuts (*Juglans regia* L.), almonds [*Prunus dulcis* (Mill.) D.A. Webb.], and hazelnuts (*Corylus avellana* L.)}. The Institute also has collections of dates (*Zizyphus jujuba* Mill.), figs (*Ficus carica* L.), persimmons (*Diospyrus kaki* L.), pomegranates (*Punica granatum* L.), and other fruits (Esenbaev et al., 1981).

The Institute has developed and released 150 cultivars of fruits, berries, and grapes. In addition, 58 advanced selections are nearing release. Cultivars developed by the Schroeder Institute have been widely accepted by Uzbek commercial growers: 80% of the apples, 60% of the pears, 69% of the grapes, 90% of the strawberries (*Fragaria ×ananassa* L.), 65% of the quince (*Pyrus cydonia* L.), 65% of the peaches, 90% of the black currants (*Ribes nigrum* L.), and 90% of the nuts in Uzbekistan are cultivars released by the Institute. Some are widely grown throughout the former USSR.

The present goals of the Institute include the following.

1. Develop new cultivars of orchard crops and grapes that produce high yields of fruit with improved quality under various climatic extremes, and also exhibit disease and insect resistance, cold-hardiness, and drought tolerance.
2. Develop cultivars for use on extremely poor soils (sandy, stony, salty, and/or dry soils).
3. Improve drying technology and storage methods for fruits and grapes (i.e., raisins).
4. Develop new farm machinery for orchards and vineyards.

Fig. 4. Apricot 'Ubileini Navoi'.

Breeding Strategies Used at the Schroeder Institute

Apricots. In 1930, a systematic and comprehensive breeding program was initiated. Initial evaluations identified three cultivars, 'Kursadik', 'Arzami', 'Ruhi djuvanon', and two European cultivars, 'Krasnoshoki' and 'Korolevski', as resistant to the widely fluctuating climatic conditions common in Uzbekistan, especially flower and fruit damage due to late spring frosts (Kovalev, 1963). Schroeder Institute plant breeders developed new apricot cultivars with late flowering and high fruit quality by selecting from hybrids between local landraces and European cultivars. Six frost-tolerant cultivars were developed and released: 'Samarqandski ranni', 'Medovi', 'Uzbekistansky', 'Ubileini Navoi' (Fig. 4; Table 1), 'Samarqandski # 117', and 'Zarafshansky pozdni' (Mirzaev and Kuznecov, 1984; Mirzaev et al., 1983). The cultivar 'Ubeleini Navoi', which originated from a cross between 'Arzami' and 'Falgarsky gulungi', has a reputation for high fruit quality and yield.

The first cultivars that were developed displayed flower bud resistance to cold, but did not produce consistently acceptable crop yields. Later, scientists developed new, late-blooming apricot cultivars, including 'Gulistan', 'Navruz', 'Avicena', 'Zarafshansky pozdnii' (Table 1), 'Abadi', 'Nuravshon', and 'Mohir' (Mirzaev, 2000; Mirzaev and Kuznecov, 1984; Turakulov, 1993), that had a higher chilling requirement and were later blooming than the previous cultivars. They had, concomitantly, greater resistance to frost and consistently good fruit yields. The first bloom is at least 1 week later than the 'Ubelini novai' and 'Kursadik' cultivars (Mirzaev, 2000).

Table 1. Characteristics of late flowering and/or frost-tolerant apricots.

Cultivar	Avg fruit wt (g)	Fruit color	Years to fruit production	Yield ($t \cdot ha^{-1}$)	Ripening time	Major end use
Gulistan	33	Bright golden with ruddiness	4	10	Early June	Dried apricots
Navruz	40	Partly yellow, with dark red skin	5	10	Early July	Fresh and canned
Avicena	45	Light pink	5	10	Late June/ early July	Dried, fresh, and canned
Zarafshansky pozdnii	40	Yellow with small dark streaks	5–6	13	Late July	Dried
Ubileini Navoi	45	Gold-yellow with large bright streaks	4	14	Late June/ early July	Fresh, canned, and dried

Table 2. Characteristics of selected peach and nectarine cultivars.

Cultivar	Avg fruit wt (g)	Fruit color	Years to fruit production	Yield (kg/tree)	Ripening time
Malinovi	Up to 300	White with pink streaks	5–6 years	60–80	August
Nectarin jelti	70	Light yellow	2–3, full in 5 years	120	Late August
Podarok Uzbekistana	160	Golden yellow	3	120	Late July/ early August
Farhad	Up to 400	Dark yellow	3	130	September
Shirin magiz (saucer shape)	Up to 150	Orange with pink streaks	3	130–140	July
Nectarin tashkentsky	65	Orange	5	115	Mid-July

Table 3. Characteristics of selected apple cultivars.

Cultivar	Avg fruit wt (g)	Fruit color	Years to fruit production	Yield ($t \cdot ha^{-1}$)	Ripening time	Major end use	Flavor
Afrosiabi	100–150	Golden-yellow with streaks of orange-red	4–5	15–17	1–10 July	Fresh	Acid-sweet with pleasant aroma
Borovinka Tashkentskay	140	Greenish-yellow with dark pink stripes	4–5	16–18	10–20 July	Fresh	Acid-sweet
Nafis	160–180	Greenish-yellow with slight pink patches	3	20–22	Early October	Fresh	Sweet
Pervenece Samarqandat	90	Golden-yellow	3–4	15–17	Early June	Fresh	Acid-sweet
Saratoni	120–150	Light green with slight red flecks	4–5	14–16	1–10 July	Fresh	Acid-sweet with aroma
Hasildar	150–200	Light green with yellow shade	2–3	18–20	1–10 June	Fresh	Acid-sweet

Peaches and nectarines. The peach-breeding program focused on the improvement of cold-hardiness and consistent yields. Using parents from various geographical regions, the first releases were developed via recurrent hybridization and selection. Although improved in cold hardiness and yield consistency, they lacked fruit quality, postharvest life, and fruit uniformity needed for canning.

Later cultivars with improved disease resistance {leaf curl [*Taphrina deformans* (Berk.) Tul.] and powdery mildew (*Sphaerotheca pannosa* Lev.f. persicae Woroich.)}, cold hardiness, and high fruit quality were developed (Cherevachenko, 1960). The primary focus was on yellow-fleshed freestone cultivars. Characteristics of selected peach cultivars are shown in Table 2. Fruit of these cultivars were used in a variety of ways, for example, as fresh, dried, and canned. The Schroeder Institute has developed and released more than 70 new peach and nectarine hybrids having high fruit quality (Mirzaev, 1993).

Apples. The main objective of the apple-breeding program has been to develop improved resistance to cold temperatures during the spring, fall, and winter, and to high summer temperatures. The overall goal is the year-round availability of high quality table apples using a combination of early-, mid-, and late-maturing cultivars.

The apple-breeding program was started by hybridizing local cultivars and landraces resistant to cold temperatures with cultivars from throughout the world. Subsequently, crosses and backcrosses were made with the progeny of the initial hybrids and cultivars displaying the desired characteristics. Breeders used mixed pollen from U.S. and European cultivars to produce the hybrids with the assumption that selection pressure (e.g., low temperature) applied to a heterogeneous population of pollen will lead to more desirable fertilization events and subsequent hybrid plants. Open-pollinated progeny from these hybrids were then subjected to selection. As a result, 29 cultivars were released. The characteristics of the most notable apples are shown in Table 3 (Schroeder, 1993).

Pears. The primary objectives of the pear-breeding program have been summer heat tolerance, drought resistance, and high fruit quality. In the early 1940s, crosses were made among cultivars from several geographical regions representing widely divergent climatic zones. Individual trees displaying the best overall performance were selected and intercrossed, followed by further selection. The characteristics of the most notable Uzbek cultivars developed in this program are described (Table 4), Mirzaev at al. (1983).

Grapes. Uzbekistan is among the oldest grape-growing regions in the world. The best known grapes of Uzbekistan are cultivars used both as fresh table grapes and for dried raisins. The diversity of table grape/raisin cultivars maintained at the Schroeder Institute is considered to be among the highest of comparable organizations worldwide, the

Table 4. Characteristics of selected pear cultivars.

Cultivar	Avg fruit wt (g)	Fruit color	Years to fruit production	Yield ($t \cdot ha^{-1}$)	Ripening time	Major end use
Podarok	150–170	Light yellow with red blush	4	17	10–20 Aug.	Fresh, dried, and canned
Rano	170	Light yellow	5–6	17–18	September	Fresh and dried
Zimnay (Nashvati-2)	200–350	Light green with ruddiness	4	18	1–15 Oct.	Fresh, with shelf life until 15 Mar.
Kulyly	400–1000	Light green	4–5	16–18	1–15 Oct.	Fresh
Sari guzal	230–265	Light green with yellow shade	4	17	1–20 July	Fresh

Table 5. Characteristics of selected grape cultivars.

Cultivar	Avg fruit wt (g)	Avg cluster wt (g)	Time of ripening	Soluble solids (%)	Fruit color	Yield ($t \cdot ha^{-1}$)	Major end use	Seeded/ seedless
Ranni Shredera	4.5	350–400	July–August	18–20	Light violet	14–16	Fresh	Seeded
Rizamat	5+	300–350	15 Aug.	20	Pink	15–18	Fresh, dried, canned	Seeded
Kishmish Zarafshan	5–6	350–400	20–30 Aug.	20–24	Light green	14–16	Fresh, dried	Seedless
Kishmish Samarqand	3.5	200–230	10–20 Aug.	19–20	Light green	12–14	Fresh, dried	Seedless
Ertapishar	2.5	220	Early July	15–16	Dark pink	8–10	Fresh	Seeded
Kishmish Terakli	2.5	250	Late August	25–27	Black	14–15	Fresh, dried	Seedless
Kishmish Duoba	4	300–350	Mid-August	22–24	Dark blue	15–17	Fresh	Seedless
Husaine muskatni	7	500	Mid-August	20–22	Light green	16–18	Fresh, dried	Seeded

number totaling >1300 advanced accessions (Esenbaev et al., 1981).

The main goals of the Institute's grape breeding program have been to improve fruit and fruit cluster quality and genetic resistance to diseases and insect pests. The ideal table grape cultivar is characterized by large fruit clusters comprising large seedless individual fruit (Smirnov, 1985).). Since 1986, breeders at the Institute have developed and released more than 20 new cultivars (Djavacynce, 2001). The characteristics of the most important cultivars are described in Table 5 (Mirzaev et al., 1984). A photograph of the seedless grape 'Kishmish Zarafshan' is shown in Fig. 5.

Cherries, plums, strawberries, European black currants, and Chinese dates. The Schroeder Institute also developed many new cultivars of cherry (*Prunus avium* L. 'Bahor'); plum ('Chernosliv Samarqandski'); strawberry ('Uzbekistanskay', 'Pamyt Shredera', and 'Krasavica Uzbekistana'); European black currants ('Plotnomyasnay', 'Kishmishnay', and 'Dustlik'); and Chinese dates (Melkoplodnii kislii #1', 'Krupnoplodnii #1', 'Ubilenii', and 'Dargomsky') (Mirzaev at al., 1983).

Nut species. Kalmikov (1968) reports that there are five major species of nuts grown on 32,000 ha in Uzbekistan. Of this, 84% consists of harvests in wild forests, and 16% is cultivated.

Pistachios (*Pistacia vera* L.). Pistachios represent the largest nut crop in Uzbekistan and are harvested mostly from the wild. The total area is ≈25,000 ha, mostly concentrated in Surkhondaryo Province. The average yield is 0.5 to 1.5 kg/tree. Breeders located at the Institute's Bostandik Branch have developed more than 30 cold-hardy cultivars (Kalmikov, 1968).

Walnuts. Walnut is the second largest nut crop in Uzbekistan. The total area of walnut production is 4500 ha (400,000 trees), of which 89% are in Tashkent Province, 5% in Surkhondaryo, 4% in Samarqand, and 2% in Farghona and Andijon Provinces. Wild trees yield ≈10 kg/tree, while cultivated trees yield in the range of 100 to 500 kg/tree, resulting in an average yield of 2.0 to 2.5 $t \cdot ha^{-1}$. Walnut breeding research facilities are located at Institute branches in Tashkent (Bostandik) and Samarqand (Kalmikov, 1968).

Breeders at the Institute's Bostandik branch have developed or selected the following walnut cultivars: 'Bostandiksky', 'Rodina', 'Gvardeisky', 'Tenkoskorlupnii' (Fig. 6), 'Ideal', 'Uzbeksky kruponoplodii', 'Kazahstansky', and 'Panfilovece'. The above cultivars have high nut quality, high yield, precocious fruit maturation, resistance to diseases and insects, and cold hardiness (Kalmikov, 1968).

Almonds. Cultivated almonds are grown mostly in the Tashkent and Surkhondaryo provinces and are harvested from the wild in the Samarqand and Surkhondaryo provinces. The total land area of almonds in Uzbekistan is more than 2500 ha, ≈1000 ha of which is cultivated. The best trees have a yield of 20 to 30 kg/tree of dried nuts (Kalmikov, 1968).

Breeders at the Bostandik branch of the Institute developed new genetic lines using hybridization followed by selection, primarily for spring frost tolerance. To date, they have released 11 new almond cultivars. The most widely grown cultivars are 'Pervenece', 'Kolhoznii', 'Rannii', 'Tyn-Shansky', 'Sablevidnii', 'Kosmichesky', 'Ugamsky', and 'Krasivii'. These cultivars feature cold hardiness, frost resistance, and resistance to fungal diseases.

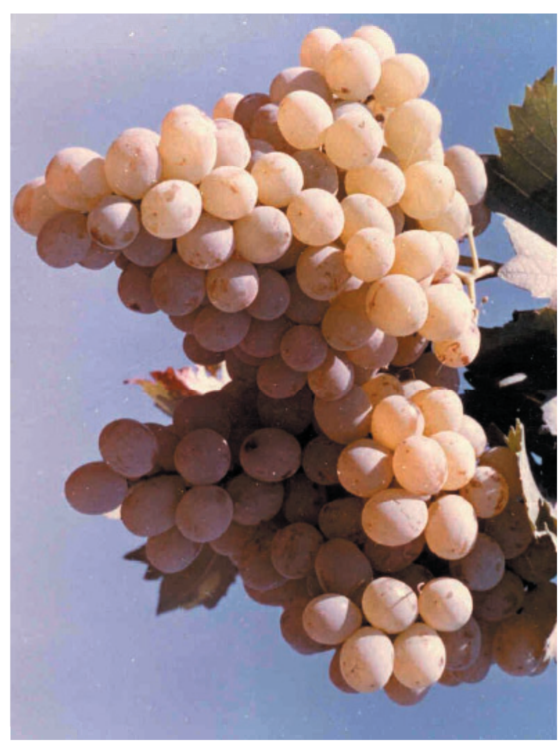
Pecans (*Carya illinoinensis* Nutt). Pecans were introduced into Uzbekistan in 1934. Institute breeders have developed new pecan cultivars with superior qualities, specifically with 60% to 66% nut oil content. The best of these cultivars are 'Urojainii', 'Uzbekistan', and 'Pamyt Shroedera'. However, pecans are not currently widely grown in Uzbekistan (Kalmikov, 1968).

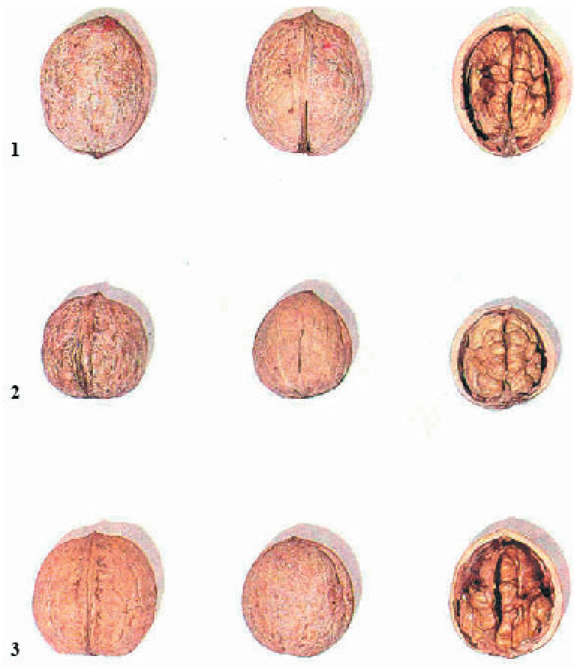
Hazelnuts. The European hazelnut was introduced in the mid 1800s and, like pecans, hazelnuts are not yet widely grown in Uzbekistan. Breeders located at the Institute's Bostandik branch have selected clones from the best accessions introduced from the Caucasus region (Kalmikov, 1968).

Conclusions

The objectives of many breeding programs to develop larger, higher yielding, and better storing fruit and nut crops have dramatically narrowed the genetic base of these species. The vast genetic diversity that has been collected and maintained at the Schroeder Institute in Uzbekistan is a valuable resource for fruit and

Fig. 5. Seedless grape 'Kishmish Zarafshan'.





.Fig. 6. Walnut cultivars: 1) 'Bostonliksky pozdnocvetushii', 2) 'Uzbeksky skoroplodnii', and 3) 'Tonkoskorlupnii'.

nut breeding programs worldwide. The fruit breeding programs at the Schroeder Institute have used local cultivars, landraces, and at times, U.S. and European cultivars, to develop breeding lines and finished cultivar releases with increased disease resistance, cold-hardiness, and high quality. These cultivars, as well as the other genetic resources maintained at the Schroeder Institute, will be useful to develop novel genotypes with even greater tolerance to biotic and abiotic stresses in the future. Scientists interested in gaining access to these genetic resources should contact the Schroeder Institute.

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