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BREEDING AND GENETICS

Uzbek Scientific Research Institute of Cotton Breeding and Seed Production: Breeding and Germplasm Resources

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ABSTRACT

The Republic of Uzbekistan, whose extensive plantations supplied nearly all of the cotton (*Gossypium barbadense* L. and *G. hirsutum* L.) needs of the Soviet Union, has a long history of cotton research, genetic improvement, and production. Uzbekistan currently ranks fifth in total world cotton production, with more than one million metric tons of cotton fiber produced per year, and is second in total world cotton export, surpassed only by the U.S. Accordingly, the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production, located in Tashkent Province, the Republic of Uzbekistan, is the largest and most comprehensive cotton research station in Central Asia. Its history, scientific activities, and germplasm resources are described here.

Since the early 1800s until the break up of the Soviet Union in 1991, Central Asia remained generally inaccessible to the western world. Only recently have its rich germplasm resources and achievements of its plant scientists become more widely known and accessible. The Republic of Uzbekistan, whose extensive plantations supplied most of the cotton (*Gossypium barbadense* L. and *G. hirsutum* L.) needs of the former Soviet Union, has a long history of cotton genetic improvement, research, and production. Uzbekistan currently ranks fifth in total world cotton production, with more than one million metric tons of cotton fiber produced per year, and is second in total world cotton export, surpassed only by the U.S. (FAS/USDA, 2007). Accordingly, the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production, located in Tashkent Province, the Republic of Uzbekistan (Fig. 1), is the largest and most comprehensive cotton research station in Central Asia.

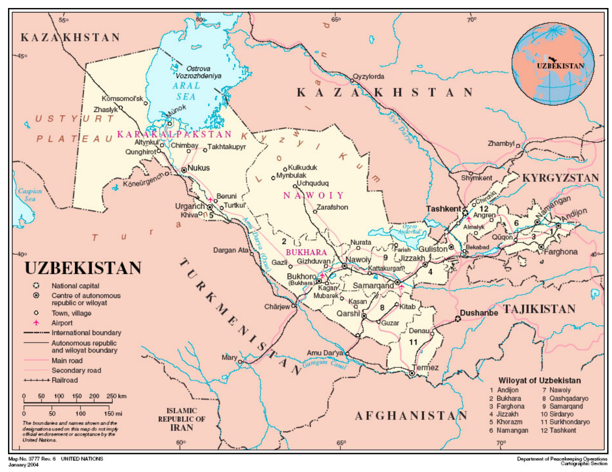

Figure 1. Map of the Republic of Uzbekistan (reproduced with permission from the Department of Peacekeeping Operations, Cartographic Section, United Nations, Map No.3777 Rev. 6, Jan. 2004).

The Institute, originally named the Turkestan Breeding Station, was established in 1922 where it focused on cotton and other agronomic plant species (see Table 1 for a chronology of the Institute's names). The main goals of the Institute in its early years were the collection and storage of seeds and the evaluation of germplasm collected from around the world under the various climatic zones of Uzbekistan. Since 1922, the Institute has developed into a major cotton research and breeding center, culminating in the release of numerous successful cotton and alfalfa (*Medicago sativa* L.) cultivars, along with advancing the science and technology of cotton classification, genetics, breeding, cytology, physiology, and biochemistry, as well as cotton

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production and management. At the present time, 11 cotton cultivars developed at the Institute are planted commercially in Uzbekistan, which includes 10 cultivars of *G. hirsutum* and one of *G. barbadense*. These cultivars occupy approximately 40% of the total area planted to cotton in Uzbekistan each year (Table 2). Cumulatively since its establishment, more than 66 million hectares of land have been planted with cultivars developed at the Institute.

The first director of the Institute was Gavriil S. Zaitsev (1922–1929). He is most renowned for his work on cotton classification and systematics, which has been recognized and used internationally, as well as his work on cotton biology (environmental effects on phenology), physiology, and genetic improvement (Muratov et al., 1975). In addition to cotton, Dr. Zaitsev worked with corn (*Zea maize* L.), alfalfa, peanuts (*Arachis hypogaea* L.), and sesame (*Sesamum indicum* L.). One focus of his research was to develop methods to utilize tropical perennial forms of cotton as an annual crop. As a result of this work, breeders later developed hybrids of perennial tropical forms and annual forms that performed well under Central Asian conditions. Dr. Zaitsev also developed many early maturing, long-fibered cotton cultivars including 705, 182 (Ak-Djura), and 169 (Dehkam). In addition, he collected large quantities of cotton germplasm worldwide, establishing the now extensive germplasm collection held at the Institute (Muratov et al., 1975 ; Abdullaev et al., 2007).

In 1930, the Turkestan Breeding Station became part of the newly founded All Union Scientific Research Institute of Cotton and was designated as its main cotton breeding station. At this time Dr. Sergey Kanash became the second director of the Institute, and he held the position until 1965. Dr. Anatoly I. Avtonomov served as head of the cotton breeding department from 1930–1955 and was also head of the cotton department at the Tashkent Agrarian Institute (now called Tashkent State Agrarian University) from 1946–1968. He established methods for hybridizing wild and cultivated *G. barbadense* lines to develop cultivars with large bolls and resistance to *Fusarium oxysporum* f. sp. *vasinfectum* W.C. Snyder & H.N. Hansen. By the end of the 1930s he developed the Sea-Island–type cotton cultivars 35-1 and 35-2. Later he released the high yielding, extra long staple cultivars 2836, 2850, 10954, 6002 and 6022 (Avtonomov, 1930, 1948, 1960). Dr. Avtonomov was the first breeder to identify determinate branching cotton plants in the former Soviet Union, which he utilized in his breeding program (Avtonomov, 1973). During his career, Dr. Avtonomov developed many early maturing cultivars that expressed disease resistance along with high yield and high fiber quality and as a result was awarded many state honors.

Table 1. Chronology of the names of the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production

Name of Institute	Years
Turkestan Breeding Station	1922–1930
Main Breeding Branch of the All Union Scientific Research Institute of Cotton	1930–1965
Scientific Research Institute of Cotton Breeding and Seed Production	1965–1971
G.S. Zaitsev Scientific Research Institute of Cotton Breeding and Seed Production	1971–1992
Uzbek Scientific Research Institute of Cotton Breeding and Seed Production	1992–present

Table 2. Cotton Production in the Republic of Uzbekistan

Year	Area of cotton planted, ha		[z]Cultivar %	Yield, including seeds, ton/ha	
	G. hirsutum	*G. barbadense*		*G. hirsutum*	*G. barbadense*
2003	1,372,700	26,100	42.6	2.35	1.96
2004	1,445,800	10,300	39.5	2.47	2.10
2005	1,460,700	13,000	37.6	2.55	2.22
2006	1,424,400	21,100	42.7	2.68	2.43
2007	1,381,400	10,000	38.2	3.10	2.95

[z] **Percent of total land area planted to cultivars developed by the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production (data based only on *G. hirsutum*).**

In 1960, while still functioning as a branch of the All Union Scientific Research Institute of Cotton, the Institute was reorganized and its focus was expanded to include alfalfa breeding and seed production. Alfalfa, which is native to Central Asia, was included because it is the primary cover crop used in rotation with cotton in the former Soviet Union. The main alfalfa breeding objectives were to develop new high-yielding cultivars that expressed increased protein content. During this time, the Institute also established a substantial alfalfa germplasm collection.

In 1965, the Institute became independent of the All Union Scientific Research Institute of Cotton and was subsequently renamed the Scientific Research Institute of Cotton Breeding and Seed Production. At this time Dr. Shukur Ibragimov became director and served until 1976. During his span as director, Dr. Ibragimov was actively involved in the cotton genetic improvement program and was the codeveloper of the following economically important cultivars of *G. hirsutum*: Kizil-Rovat, Uichi, Andijzan-60, C-7510, C-7512, Akkurgan-6, Fergana-5, and C-8288; and *G. barbadense*: C-6029, C-6030, C-6037, C-6040, Termez-14,Termez-16, and Termez-31 In 1987, Dr. Ibragimov was awarded the prestigious Beruni State Award for developing the early-maturing (124–127 d) and high-yielding (up to 5 ton/ha, including seeds) Termez-14.

Dr. Anatoly I. Avtonomov's sons, Alexander and Vadim, continued their father's breeding activities at the Institute in the 1950s and 1970s, respectively. Dr. Alexander Avtonomov served as vice-director and department head (starting in 1965) and developed cultivars of *G. barbadense* with even greater *F. oxysporum* resistance than those released earlier. He also codeveloped Kizil-Rovat with Dr. Ibragimov, which was grown on approximately 100,000 ha annually in Uzbekistan for many years. Later, in cooperation with his brother Dr. Vadim Avtonomov, he developed 'C-6524' through the hybridization of '159-F' and a selection of *G. hirsutum* L. subsp. *punctatum* (Schumach. & Thonn) Mauer. For 15 years (until 2004), C-6524 occupied approximately 250,000 ha/yr in Uzbekistan. This cultivar was found to be very resistant to the two most virulent races of *Verticillium dahliae* Kleb.

Dr. Vadim Avtonomov, in addition to the joint release of C-6524 with his brother, individually developed and released 'C-6530' and 'Namangan-77' in the 1970s, for which he was awarded the Beruni State Award from the Republic of Uzbekistan in 1996. These three cultivars were noted for their high yield and fiber quality, early maturity, and disease resistance.

Dr. S.M. Mirakhmedov became director of the Institute in 1976 and held this position through 1987. During this time he was instrumental in the development and release of the successful Tashkent series of cultivars known for their increased resistance to *Verticillium dahliae*. The Institute continued to grow and in 1977 reached the level of an All Union Scientific Research Institute. It now functioned as the main center for cotton breeding and seed production across the entire Soviet Union. By 1987 the Institute developed two fully equipped branch stations, one located in Kizil-Rovat, Namangan Province, and the other in Surkhan, Surkhandarya Province, Uzbekistan. In 1990 a third branch station was built in Akkurgan, Tashkent Province (Fig. 1). These branch stations facilitate evaluation of plant material across the different climatic zones of Uzbekistan (P. Ibragimov, 2002; Sh. Ibragimov, 1972).

Throughout its history, many distinguished scientists conducted research at or collaborated closely with the Institute. In addition to those already mentioned, the list of collaborators includes Dr. M. Mauer (the breeder who developed the cotton classification system with Dr. Zaitsev); the breeders C.C. Kanash, B.P. Straumal, U.P. Khutornoi, A.M. Maltsev, K.A. Vitsotsky, and A.D. Dadabaev; the geneticist Dr. L.G. Arutunova; the systematist Dr. A.M. Raikova; the cytologist Dr. V.I. Tsivinsky; the soil scientist Dr. P.A. Baranov; and the breeder and management specialist Dr. A.I. Belov, as well as others (Straumal, 1974).

Since its establishment, the Institute has released over 200 cotton and eight alfalfa cultivars. Thirteen were released and commercialized after Uzbekistan became an independent republic in 1991. These include the *G. hirsutum* cultivars Fergana-3, Karshi-8, C-6524, C-6530, Namagan-77, C-6532, Omad, Akkurgan-2, and C-2609 and the *G. barbadense* cultivars Surkhan-9, Surkhan-100, Surkhan-101, and Surkhan-12. At the present time, the Institute is releasing new cotton cultivars at a rate of one to two per year (Table 3). Recent *G. barbadense* cultivars developed at the Institute generally have type I fibers (see Table 4 for description of fiber types) and are characterized by high yield (4–5 ton/ha with seeds), micronaire values of 3.7 to 4.2, 34 to 36% fiber content, early maturation (117–122 d from germination to harvest), and high resistance to *Fusarium oxysporum* f. sp. *vasinfectum*.

Table 3. Characteristics of recently released cotton cultivars developed by the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production

Cultivar	Species	Parentage	Number of days from 50% germination to 1st ripe boll (d)	Avg. boll wt (g)	Yield (ton·ha^{-1})	Fiber (%)	Plant height (cm)	Technological characteristics of fiber			Ave. response to wilt organisms (% of planting expressing disease symptoms*)	
								Micronaire	Length (mm)	Strength g/tex	Mildly susceptible	Highly susceptible
Namangan-34	*G. hirsutum*	Hybrid of germplasm collected from geographically distant regions C-1973' × 02654 (subsp. *punctatum*)	118-120	6.0–6.5	34.1–48.7	39.0	120–130	4.0–4.3	29.2	27.2	12.4	3.1
C-6541	*G. hirsutum*	'C-6530' × 'C-6524'	117-121	5.5–6.0	37.8–53.4	41.0	110–120	4.3–4.5	28.7	26.4	7.8	1.7
Turon	*G.hirsutum.*	Complex hybrid [F_5 ('Deltapine' × 'Morill') × F_5 ('Panmaster 266' × 'Richmondi')]	115-117	6.0–6.5	32.0–42.0	36.5–37.5	110	4.3	28.7	26.0	10.2	2.1
C-9076	*G.hirsutum*	Selection from 'S9063'	118-120	6.5	4.5–5.0	38–38.5	120–125	4.0	28.5	26.8	12.1	0
At Termiz	*G. hirsutum*	Selection from 'Akkurgan-2'	115-120	5.0	38–45.0	37.0	115–120	4.3–4.5	28.5	25.8	7.0	4.0
C-6771	*G. hirsutum*	'C-9070' × 'L-77'	115-117	3.8–4.2	30.9–42.2	36.5	90–100	4.4–4.5	29.5	26.5	17.0	4.3
C-2610	*G.hirsutum*	'L-392' × 'L-154'	120-122	6.5	39.0–52.0	36.6	110–115	4.2	28.2	25.9	8.0-9.0	1.0–1.5
Surkhan-9	*G. barbadense*	Hybrid of germplasm collected from geographically distant regions ML-101 × 07630	117-120	3.4–3.7	38.4–53.7	34.0	100–110	3.9–4.2	35.5–36.0	37.2	1.3	0
Surkhan-101	*G. barbadense*	Hybrid between lines L-500 × ML-104	115-119	3.3–3.5	41.2–55.6	35.1	90–100	3.8–4.1	35.5–35.8	34.3	1.2	0
Surkhan-14	*G. barbadense*	'Ashkhabad-53' × 'Karshi-6'	117-120	3.4	40–42.0	37.0	100–120	3.7–4.1	33.0–33.5	36.8	2.1	0

***Refers to G. *hirsutum* response to Verticillium *dahliae* var. nervosum and G. *barbadense* response to Fusarium *oxysporum* f. sp. vasinfectum.**

Table 4. Description of cotton fiber type classifications used in the cotton producing countries of the former Soviet Union. Classifications are primarily based on textile industry requirements (Abdullaev et al., 1989; Gataulina, 1997)

Fiber type	Length (mm)	Micronaire	Strength (g/tex)	Use in industry	Cultivar
I	39−41	3.0	36.0	parachute fabric, cambric, zephyr cloth, jersey knit, very strong thread	Ash-25, 9883-I, 9871-I
II	37−38	3.5	35.5	percales, stockings and socks, velvet, nainsook, strong cotton cord	6465-V, S-6037
III	35−37	3.7−4.2	35.0	specialty threads, scarves, crepe, high-quality sateen	Surkhan-9, Surkhan-101, Surkhan-14
IV	33−35	4.2−4.5	34.5	chiffon, zephyr cloth, poplin, jersey knit, yarn	159-F, C-6524, C-6530, C-9070, Akkurgan-2
V	31−33	4.5−4.9	34.0	coarse calico (mitkal), chintz, sateen, reps, gauze, cheap cotton goods	C-4908, C-4909, C-4908, C-4910, C-4911, C-4912, C-4914, Mustakil-1, C-6770
VI	31−32	4.5−5.0	33.0	melange fabrics, baize, cheap cotton goods, fustian, towels, diagonal cloth	Andijon-60, S-4880

The Institute has the only alfalfa breeding and seed production program in Uzbekistan. The collection currently holds more than 6000 advanced accessions, making it one of the largest alfalfa collections in the former Soviet Union. Notable alfalfa cultivars developed at the Institute are Tashkentskaya-3192, Tashkentskaya-1, Tashkentskaya-1728, and Tashkentskaya-721 (Table 5).

Table 5. Characteristics of alfalfa cultivars developed by the Uzbek Scientific Research Institute of Cotton Breeding and Seed Production

Cultivar	Species	Parentage	Hay yield (t/ha)	Maturity type
Tashkentskaya 1	*Medicago asiatica* Sinskaya	'Markhamadskaya' × 'Tashkentskaya 3192'	~25	mid
Tashkentskaya 721	*M. mesopotamica* Vassilcz (*M. sativa*) × *M. asiatica*	Mass selection of hybrids between *M. mesopotamica* and Central Asian accessions	18−22	early
Tashkentskaya 3192	*Medicago polia* Brand. (*M. sativa*)	Mass selection from Peruvian accessions open pollinated with Central Asian accessions	18−21	early
Tashkentskaya 1728	*Medicago sativa* × *M. asiatica*	Hybrid of 'Moapa' and local Central Asian accessions	~25	mid

The current scientific activities of the Institute include the study of cotton and alfalfa genetic resources with an emphasis on introduction, selection, and breeding to increase yield and quality of cotton fiber, as well as for improved disease and pest resistance (predominantly to *Verticillium dahliae* and *Fusarium oxysporum*). The Institute cooperates with breeding organizations in many countries and regularly organizes germplasm collection expeditions within countries of the former Soviet Union and elsewhere around the world.

Structure of Institute. The Institute consists of five departments with 15 laboratories having total personnel of 205, of which 63 are Ph.D. scientists. The Institute includes a graduate school for breeding, genetics, and seed production, and grants Doctor of Philosophy and Doctor of Science degrees in these fields of study. Since its inception in 1922, nearly 200 students have been awarded advanced degrees. During its history, the Institute has published 75 proceedings, as well as many notable monographs, recommendations, and scientific articles. The five departments include the Department of Cotton Germplasm Evaluation and Research; the Department of Upland Cotton Breeding; the Department of Extra Long Staple Cotton Breeding; the Department of Cotton Seed Research and Production; and the Department of Scientific Technical Information, Cooperative Extension Services, Patents, Licensing and Marketing.

Department of Cotton Germplasm Evaluation and Research. This comprehensive department is the largest of the Institute. It consists of six laboratories: Genetics and Cytology; Germplasm Collection and Initial Material; Genetics of Disease Resistance; Controlled Climate Research; Cotton Mutagenesis; and Biochemistry and Biotechnology.

Laboratory of Genetics and Cytology. The objectives of this laboratory are to study the theoretical and applied genetics and cytological characteristics of cotton with the purpose of developing recombinants with desirable characteristics useful in breeding. Intra- and interspecific hybridizations have been conducted between accessions collected from populations originating in distant geographical regions. The development of cultivars with genetic resistance to *Verticillium dahliae* and spider mites (*Tetranychus* spp.) are among the major breeding advances developed in this lab.

Using traditional breeding techniques, wilt resistance genes were transferred from *Gossypium hirsutum* subsp. *mexicanum* var. *nervosum* Mauer into the Tashkent series of cultivars, which includes Kizil-Rovat and others (Mirakhmedov, 1982). In addition, methods have been developed for creating polygenomic hybrids, while avoiding interspecific sterility, and to determine the most effective hybridizations to be made with cultivated cotton species. New tetraploid ($2n = 4x = 52$), pentaploid ($2n = 5x = 65$), and hexaploid ($2n = 6x = 78$) forms of cotton have been synthesized. Cytological studies of this plant material were also conducted to better understand the genetic behavior of these interspecific hybrids and to determine sources of difficulties in hybridization. To further investigate these hybrids, quantitative evaluation of chromosome morphology has been conducted. The laboratory also created very useful multispecies (four or five species) interspecific hybrids that were used as donor plants to develop novel and highly diverse lines for the breeding program (Gesos, 1979; Arutunova, 1987; Arutunova and Pulatov, 1989). From this work, ongoing studies are being conducted to identify new highly productive genotypes that are early maturing and have high fiber quality. In addition, the lab has developed methods for creating hybrids without the need for emasculation (Akhmedov, 1984). It has also developed a database of genetic traits, as well as computer programs for statistical analyses of cotton genetics that have been used to enhance breeding efficiency.

Electron microscopy is used to analyze the fiber structure of cotton cultivars, hybrids, species, and subspecies. By this method, particularities in the surface topography of the fibrillar structure in the cotton fiber secondary wall and cotton fiber hydrolyzation were found to be dependant on cultivar type (early maturity or late maturity), species, ploidy level, as well as the genetic background of the hybrids. A positive correlation was found between fiber (molecular) structure and physical characteristics of cotton fibers (Rakhmankulov, 2007). Studies on heritability, variability, transgression, as well as the correlation of morphological and other characteristics of hybrids between different cotton species and cultivars have been conducted (Pulatov, 1995).

Laboratory of Germplasm Collection and Initial Material. The cotton germplasm collection is maintained by this laboratory. At the present time the repository contains 12,823 well-characterized accessions originating from 107 countries. This includes 3850 accessions from the Commonwealth of Independent States, 2838 from the U.S., 1000 from India, 914 from Mexico, 852 from Egypt, 332 from China, 281 from Iran, 202 from Peru, 186 from Pakistan, 162 from Australia, 157 from Bulgaria, 140 from Afghanistan, 138 from Ethiopia, 126 from Colombia, 114 from Brazil, and 1531 accessions from 81 other countries. The repository contains the following species: *Gossypium hirsutum*—7884 accessions, *G. barbadense*—3438 accessions, *G. herbaceum* L—620 accessions, *G. arboreum* L.—497 accessions, and 384 accessions of other species. Responsibilities of the laboratory include the collection, evaluation, and preservation (regeneration of seeds) of the germplasm.

More than 300 perennial, late-maturing, wild cotton accessions and ruderal forms of cotton are maintained in the greenhouse. Every year the Institute adds 100 to 120 new accessions from germplasm exchange and collection efforts around the world. In 2001 through 2003, a germplasm exchange program between Texas A&M University and the Institute was conducted, in which 990 accessions were received from, and 260 accessions were sent to the U.S.

This laboratory also maintains a quarantine nursery for evaluating introduced germplasm of cotton and alfalfa. Following field planting and evaluation for the presence of pathogens, insects, and other potentially threatening agents, the accessions undergo a detailed characterization of important attributes, such as resistance to diseases organisms, yield potential, fiber characteristics, maturity dates, etc. (Muratov et al., 1992). The most useful breeding material is then sent to the appropriate department of the Institute or to other scientific organizations.

From the Institute's germplasm collections, researchers have selected lines that exhibit early maturity, high yield, high fiber content and quality, high seed oil and protein content, and the absence of gossypol. Compact bush types that are better suited to higher planting densities and mechanical harvesting have also been identified. Based on detailed characterizations of their cotton genetic resources, the Institute compiled and published a series of works, including the *Catalog of Cotton Cultivars* (Muratov et al., 1992) and Wild and Ruderal Forms of *Gossypium hirsutum* L (Alikhojaeva, 1974).

Laboratory of the Genetics of Disease Resistance. This laboratory studies the patterns of inheritance and durability of genetic resistance to pathogens (especially *Verticillium dahliae*) and develops new gene donor plants that express resistance to different pathotypes (races). Work is ongoing to develop and improve methods to identify forms of cotton with different mechanisms of genetic resistance to disease. The development of initial breeding lines using a genetically diverse pool of disease resistant germplasm allows the breeding programs to develop more efficiently cultivars that express durable, high levels of resistance, in addition to other valuable characteristics including increased productivity, early maturity, and high fiber quality.

A disease screening method utilizing a complex of *Verticillium dahliae* races was developed to identify plants expressing durable resistance to different races of the pathogen. As a result, the lab developed and released cultivars resistant to *V. dahliae* race 1. This includes C-2602, C-2605, C-2606, C-2607, and C-2608. Cultivars C-2608 and C-2602 have been widely used since 1977 and C-2606 since 1981. These cultivars have type IV fibers. A new cultivar, C-2609, with type V fibers, was released and planted on 6000 ha in 2001 and 86,000 ha in 2003.

Since 1970, scientists have been isolating pathogens from wild, semiwild, and cultivated cotton plants. From this, the most virulent races of *Verticillium dahliae, Fusarium oxysporum, Rhizoctonia solani* J.G. Kühn, *Thielaviopsis basicola* (Berk. & Broome) Ferraris, and *Xanthomonas malvacearum* (E.F.S.) Dowson are maintained in a living collection. Studies to assess the virulence of *V. dahliae* strains collected from various geographical regions on different cotton cultivars have shown that there are two qualitatively different groups of the fungus. Tashkent type cultivars are resistant to race 1 and susceptible to race 2, where as cultivars 108-F and 153-F are susceptible to both race 1 and 2 (Voitenok, 1984).

Laboratory for Controlled Climate Research. The controlled climate laboratory engages in a wide variety of research topics and expedites the breeding process by using artificial climate facilities to produce three generations of cotton per year. Their facilities contain 2.15 ha of modern greenhouses where breeding and evaluation work is continued through the winter. Early evaluation and selection of *Verticillium dahliae* resistant cultivars is conducted and intensive propagation methods are used to produce hybrid seeds from which dwarf types are determined. Overall management strategies for cotton production in controlled climates are developed and studies on controlled climate efficiency are conducted to improve energy saving practices. As a result of this research, the lab developed and patented a method to use seedlings, instead of direct sowing, in the cultivation of cotton (Ikramov et al., 1989).

Laboratory of Cotton Mutagenesis. This laboratory developed methods using physical and chemical mutagenesis to create breeding lines and subsequently new cultivars that express desirable characteristics (Ibragimov, 1970). For the first time in Uzbekistan, methods were developed to apply radiation to cotton plants. In this work, cotton pollen was subjected cobalt-60. As a result, mutants expressing a wide spectrum of genetic variability and heredity were developed. From this, 'Mutant-1' was developed, which produces 9-g cotton bolls. Studies were also conducted to determine methods to keep the mutations stable, as well as to eliminate loss of viability in M1 plants after exposure to radiation (Ibragimov, 1968).

Laboratory of Biochemistry and Biotechnology. The scientific activities of this lab are divided into three major areas of research. The first area of focus is oil and protein content of cotton and alfalfa seeds. This lab developed new rapid methods to determine oil content that breeders are using to develop new cultivars that express increased oil content (Rakhmankulov, 2000). As a result of this work, new cotton lines have been developed with increased oil content and high quality fiber, along with resistance to *Verticillium dahliae* (Sodikov, 2000). The second area of research is the determination of genetic diversity of cotton cultivars using protein electrophoresis. Based on this work, a database utilizing these useful markers was created (Rakhmankulov, 2007). The lab's third research focus is the development of embryo and tissue culture breeding methods and new genetic lines. Based on these methods, hybrid lines were developed with different numbers of chromosomes and resistance to extreme conditions. Hybrids of *Gossypium hirsutum* and the wild species *G. sturtii* F.Muell., *G. thurberi* Tod., *G. raimondii* Ulbr., *G. anomalum* Wawra & Peyr., *G. davidsonii* Kellogg, *G. arboreum* L., and *G. herbaceum* L. were developed in vitro by fertilizing excised ovules and cultivating excised hybrid embryos (Daminova and Rakhmankulov, 2007; Djuraev and Daminova, 2007).

Department of Upland Cotton Breeding. This department consists of five laboratories. The overall goal of this department is to develop and introduce new cultivars expressing early maturation, high productivity, resistance to *Verticillium dahliae* and *Fusarium oxysporum*, as well as resistance to environmental stress factors. This department also contains the alfalfa breeding and seed production lab.

Laboratory of Fiber Type IV. The main goal of this lab is to develop and release new cultivars with type IV fiber that are highly productive and disease and insect resistant, with fiber lengths of 34 to 45 mm and maturation rates of 115 to 125 d. To be accepted, the yield of new cultivars should exceed that of the old cultivars by 10 to 15%. Scientists in this lab developed methods to more effectively breed Upland cotton cultivars resistant to the most virulent races of *Verticillium dahliae* and *Fusarium oxysporum* f. sp. *vasinfectum* (Egamberdiev, 1999). Based on intraspecific hybridization between germplasm of *G. hirsutum* subsp. *punctatum* collected from distant geographic areas, and the cultivar 159-F, the improved cultivars C-6524, C-6530, C-9070, and Akkurgan-2 were developed and released.

Laboratory of Fiber Type V. This lab consists of two groups of scientists who work to develop and introduce cultivars of Upland cotton with type V fiber, which is the most widely utilized fiber type in the textile industry. New cultivars must be early maturing, highly productive, disease and pest resistant, and have fiber lengths of 31 to 32 mm and micronaire values of 4.5 to 4.7. More than 60 cultivars have been developed in this lab, some of which currently occupy a large percentage of the area growing cotton in Uzbekistan. In recent years the lab has developed cultivars with high fiber quality and *Verticillium dahliae* resistance. The cultivars C-4908, C-4909, C-4908, C-4910, C-4911, C-4912, C-4914, Mustakil-1, and C-6770, are under evaluation by the State Variety Testing Commission.

Studies conducted in this lab support the hypothesis that it is possible to develop new cultivars with desirable characteristics by crossing genetically distant species. The donor species *Gossypium trilobum* Skovst., *G. thurberi*, *G. aridum* (Rose & Standl.) Skovst., and *G. hirsutum* subsp. *purpurascens* were identified as being resistant to *Verticillium dahliae*. The wild species *G. australe* F. Muell., *G. herbaceum* var. *africanum* Mauer, *G. stocksii* Mast., and *G. klotzschianum* Andersson, which have resistance to aphids and spider mites, were also identified for use as donors. To increase the genetic diversity and wilt resistance of cotton cultivars, hybrids between *G. hirsutum* subsp. *purpurascens* and amphidiploids of *G. hirsutum* with the wild species *G. thurberi*, *G. trilobum*, *G. lobatum* Gentry, and *G. sturtianum* J. H. Willis are being produced. A series of back crosses using improved cultivars are underway to eliminate undesirable characteristics of the wild donor species.

Laboratory for the Breeding of Early Maturation and Reduced Height. This lab's primary objective is to develop and introduce cotton cultivars that are short stemmed, early maturing, and highly productive. Cultivars are being developed that express increased boll production and high quality type IV or V fibers, along with very early maturity, while still being resistance to diseases, insects, and environmental stress. The cultivar Omad developed in this lab exemplifies these qualities, and was released to farmers in the Samarkand Province in 1999 and to Tashkent and Fergana Provinces in 2000 and 2001, respectively. In 2006 Omad was planted on more than 35,000 ha in Uzbekistan.

Laboratory for Fiber Technology. This lab studies the spinning characteristics of cotton fibers obtained from new cultivars, lines, and hybrids. Extensive research has been conducted to determine the fiber quality of new accessions. Between 1990 and 2000 the lab analyzed fiber from more than 250 accessions originating from Argentina, Australia, U.S., Egypt, India, Ethiopia, Sudan, Brazil, Mexico, and other countries. The lab uses classical methods for fiber characterization; however, the most popular methodology currently consists of express analysis of fiber qualities using the HVI-2500 produced by Motion Control, Dallas, TX. This machine can analyze 14 different fiber characteristics simultaneously.

Alfalfa Breeding and Seed Production Laboratory. This lab conducts the only alfalfa breeding and research program in Uzbekistan. The main goal of the breeding program is to develop new high yield cultivars that express quick regeneration times, high protein content, and resistance to diseases and insects. The lab also maintains the alfalfa germplasm repository. Currently, there are more than 6000 well-characterized alfalfa accessions originating from numerous geographical and ecological regions. From these collections the new cultivars Tashkentskaya-3192, Tashkentskaya-1, Tashkentskaya-1728, and others have been developed. In addition, this lab has the responsibility of producing seed of specific cultivars for distribution to farmers throughout Uzbekistan.

Department of Extra Long Staple Cotton Breeding. This department consists of three groups of scientists with the paramount objectives of developing new cultivars and introducing them to growers. Specific breeding objectives are to develop early-maturing, short-stemmed, highly productive, *Fusarium oxysporum*- and *Thielaviopsis basicola*-resistant cultivars with fibers 39 to 42 mm long, a fiber content of 34 to 36%, and micronaire values of 3.7 to 4.2. Additionally, plants are bred for maturation rates of 115 to 125 d and improved suitability to mechanized production. This department, which was pioneered by Dr. Anatoly Avtonomov in 1924, has developed 144 cultivars, of which 13 have been widely grown in Uzbekistan. Currently, the new cultivar Surkhan-9, with type I fibers, is planted on 1800 ha/yr. In addition to genetic improvement work, this lab also produced many useful manuscripts and monographs such as *Breeding of Extra Long Staple Cotton Cultivars* (Avtonomov, 1973), *Catalog of Cotton Cultivars* (Muratov et al., 1992), *Modern Breeding of Extra Long Staple Cotton Cultivars* (Kimsanbaev, 2001), and *Cotton Cultivars of Uzbekistan* (Jurabekov, 2001).

Department of Cotton Seed Research and Production. The general responsibilities of this department are to improve seed production methods for new cotton cultivars, develop methods to improve seed quality, and to conduct evaluation trials for new cultivars. The department also has the responsibility of producing seed for the State Variety Testing Commission. This department includes three labs.

Laboratory of Cotton Seed Production. The Institute maintains special research farms, located in different ecological zones, dedicated to the production of "elite seeds" (100% purity, > 95% germination, 0% weed seeds, up to 10% moisture content). The elite seeds produced by these farms are sent to this lab to be evaluated for quality and purity. The lab then certifies the seed lots that meet stringent standards. The lab also develops basic organizational principles and methodologies for modern cotton seed production and conducts studies on using selection modeling with the goal of improving selected lines.

Laboratory of Cotton Seed Science. This laboratory conducts studies to improve seed quality by using biostimulation and soaking treatments to improve seed germination rates and application of pesticide solutions with the goal of decreasing pathogens and increasing the rate and vigor of germination. Studies on planting techniques are also conducted (depth, seeds number, etc.).

Laboratory for Testing and Propagation of New Cultivars. This laboratory maintains a research nursery dedicated to the evaluation of cotton cultivars produced by this and other institutes. It also produces seed of new cultivars for the State Variety Testing Commission.

Department of Scientific Technical Information, Cooperative Extension Services, Patents, Licensing, and Marketing. This department maintains the library and demonstration hall, prepares cotton exhibits, handles all patent and intellectual property issues, prepares and publishes the proceedings of the Institute, coordinates media relations, and makes arrangements for foreign visitors.

CONCLUSIONS

Difficult economic times following the break up of the Soviet Union have taken their toll on scientific endeavors in Central Asia, limiting and putting at risk the progress made during more prosperous times. This becomes especially evident when considering plant breeding and germplasm preservation efforts where living material must be actively maintained and perpetuated. In spite of this, many dedicated, well-trained, and hard-working scientists strive to continue their legacy of scientific achievements and progress, while operating on budgets consisting of only a fraction of what they were during the Soviet era. Many of these scientists are eager to cooperate with their western counterparts and opportunities for reciprocally beneficial collaborations are growing. However, it is important the western world recognize the precarious circumstances that most Central Asian institutes operate under. Efforts are needed to help support the continuation of their work, especially in terms of preserving and utilizing their immense genetic resources.

The Uzbek Scientific Research Institute of Cotton Breeding and Seed Production is one of the largest and most comprehensive cotton research institutions in the world. It has a long and successful history of valuable cultivar introductions and distinguished research, such as the cotton classification system developed by Drs. Zaitsev and Mauer, which has been internationally recognized for nearly a century. Today, the Institute maintains and is continually expanding its germplasm repository of cotton and alfalfa, which represents as an extremely valuable resource for current and future genetic improvements of these fundamentally important crops. The scientists at the Institute look forward to developing new research collaborations and reciprocal exchanges of germplasm with cotton and alfalfa scientists and organizations worldwide.

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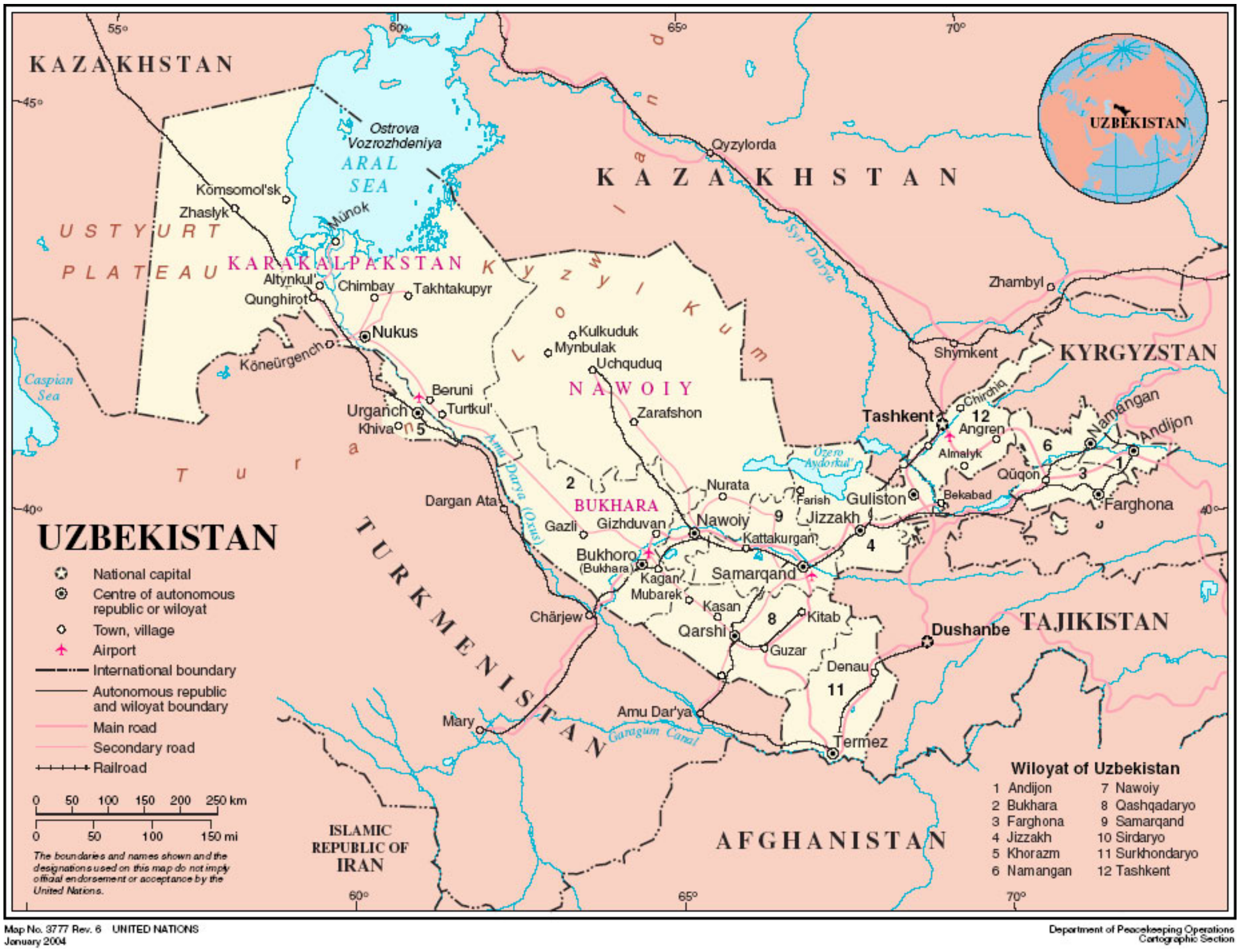

Figure 1. Map of the Republic of Uzbekistan (reproduced with permission from the Department of Peacekeeping Operations, Cartographic Section, United Nations, Map No.3777 Rev. 6, Jan. 2004).