PLANT GERMPLASM COLLECTION REPORT

Collection of Reduced-Input Turf and Forage Germplasm in the South Ural Mountains of Russia

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Country Visited/Dates: Russia, 4 August to 15 September 2008

Funding Source: USDA Germplasm Exploration Fund

Summary: Plant germplasm from the Ural Mountains of Russia is poorly represented in genebanks of the U.S. and has potential to expand existing germplasm for the improvement of turf for tolerance to drought, mowing, and low temperatures. As a result, the USDA Germplasm Exploration Fund supported a project to collect seed of possible turf species (*Poa, Festuca, Agrostis,* and *Koeleria*) in the South Ural Mountains of Russia that have potential for reduced-input turf applications in the western U.S. When opportunities arose, we also made seed collections of various grass and legume species that have potential for forage or conservation applications. A total of 185 collections covering a wide diversity of grass and legume species were made throughout Bashkortostan, Chelyabinsk, and Orenburg Oblasts of Russia.

Dr. Johnson left the U.S on 4 August 2008, arrived in St. Petersburg on 5 August, obtained an extended-stay permit from the Ministry of Foreign Affairs, and flew to Orenburg and met the three Russian team members and Ukrainian team member on 6 August. Our team began a 26-day collection trip throughout the western and eastern slopes of the South Ural Mountains. Our collection route took us from Orenburg to Kumertau, Meleuz, Ishimbay, Beloretsk, Magnitogorsk, Yuzhnoural'sk, Chelyabinsk, Kunashak, Ozersk, Kyshtym, Satki, Duvan, Karaidel, and Birsk. After our final collection near Birsk on 26 August, we drove back to St. Petersburg the next seven days via Ufa, Kazan, and Sergei Passat. We arrived in St. Petersburg on 2 Spetember. At the N.I. Vavilov Research Institute of Plant Industry (VIR) in St. Petersburg, we cleaned, weighed, and divided our seed collections with portions going to Russia, Ukraine, and the U.S. Seed collections were inspected by officials at the Federal Service for Veterinary and Phytosanitary Surveillance of the Russian Federation in St. Petersburg and given approval for export. The Ukrainian portion of the seed and herbarium specimens was hand-carried as luggage back to the Ustimovskaya Research Station at Ustimovka, Ukraine. The U.S. portion of the seed collections was delivered to Homeland Security inspectors at the Salt Lake City Airport on 15 September 2008 and sent to the USDA Plant Germplasm Quarantine Center in Beltsville, MD for processing. The seed collections were subsequently sent to Logan, UT for final cleaning and preparation of passport data. The cleaned seed and accompanying passport data will be sent to the Western Plant Introduction Station in Pullman, WA, where they will be incorporated into the U.S. National Plant Germplasm System. These collections will be available for research to scientists around the world and evaluated in breeding programs at the USDA-ARS Forage and Range Research Lab for potential use in reduced-maintenance turf, forage, and conservation applications in the western U.S.

Recommendations: Dr. Nickolai Dzyubenko (Director General of VIR) is very interested in promoting joint germplasm collection expeditions and collaborative germplasm-related research. U.S. scientists should be encouraged to establish cooperative interactions with VIR scientists. The diverse, expansive land mass in Russia and Central Asia makes this area an important area to add targeted collections of a wide range of crop plants and their wild relatives. Now is an ideal time to collaborate with VIR scientists to make additional collections from Russia and adjoining countries in Central Asia for grass and legume species for reduced-input turf, forage, and conservation applications. Collection of germplasm from this unique part of the world will insure its preservation and availability for future generations.

Acknowledgments: Dr. Vladimir Chapurin (leader of the expedition) did an excellent job of planning, organizing, and facilitating all aspects of our trip. Appreciation is extended to Drs. Victor Kir'yan, Leonid Malyshev, and Tamara Buravtseva who made numerous contributions that involved seed collection, taxonomic identification, logistical preparations, driving, cooking, and seed cleaning.

Technical Report

Introduction

Background: Russia is the largest country in the world with an area that covers about one eight of the global land area or about 1.8 times greater than the U.S. Its territory encompasses eight natural zones that include vast steppe areas, arctic deserts and tundra, taiga, broad-leaved forests, and steppe areas. Russia has more than 11,000 species of vascular plants, which constitutes about 8 % of the global vascular plant flora. Russia has about 22 % of the world's forested area or about 764 million hectares (equal to about 1.9 billion acres). Russia's vast natural resources are of global importance, both ecologically and economically.

The climate of Russia is continental with long, cold winters and brief summers. Summer and winter temperatures vary widely in Russia and precipitation is relatively low. Annual precipitation decreases from about 640-760 mm in the European region of Russia to less than 50 mm in parts of Central Asia. The tundra has long winters, with summers lasting one or two months, and receives from 8 to 12 months of snow or rain. The far northern forest, like most of the country, has long severe winters, short summers, and extremely short springs and autumns. Precipitation is generally low but falls throughout the year, varying from 530 mm at Moscow to 200-250 mm in eastern Siberia. The steppe region of Russia has very cold winters and hot, dry summers.

The Ural Mountains in western Russia run in a north-south direction that extends over 2,000 km from about 51^{o} N (near the northern border of Kazakhstan) to 70^{o} N latitude (near the coast of the Arctic Ocean). The Ural Mountains have a maximum width of about 250 km and are traditionally considered the dividing line between Europe and Asia. Geographers divide the Urals into five regions: South, Middle, North, Subarctic, and Arctic Urals. The Urals were named after the Uralian tribe that was once native to the northern region of Asia. The Urals are among the world's oldest mountain ranges with an age of 250 to 300 million years. The mineral wealth of the Urals was known to the Greeks in the Ninth Century with rich deposits of iron, copper, gold, platinum, iridium, osmium, silver, mercury, nickel, zinc, cobalt, nickel, and many precious and semi-precious stones.

The South Ural Mountain Region was the targeted collection area with the highest mountains in this area being Yamantau (1,640 m) and Bolshoi Ieremel (1,582 m). Although the flora and vegetation of the Urals have been well studied by Russian botanists, nearly all of these floral treatments are published in Russian. The eastern slopes of the South Urals are characterized by forest-steppe with numerous lakes, while the western slopes have forests up to 1,200 m elevation. The forests in this part of the Urals are usually not continuous, but are rather scattered forests interspersed with pastures. The forests in this area are dominated by *Pinus sylvestris* and mixed-deciduous tree species. The southern reaches of the South Urals grade into steppe vegetation. As a result, the vegetation of the South Ural Mountain Region represents a unique mix of floral elements from Europe, Asia, and the dry steppes of Kazakhstan.

Trip Details

Targeted species: Species of *Poa, Agrostis, Festuca, Koeleria,* and *Puccinellia* from the South Ural Mountains have potential for reduced-input turf and were targeted for collection on this collection trip. Accessions of these targeted genera in the South Ural Mountains have been exposed to heavy grazing pressure for thousands of years and, therefore, likely have developed tolerance to grazing, which would make them ideal candidates for clipping tolerance traits. Because of the long grazing history in the Ural Mountains and the large heterogeneity of habitats within this area, grass collections may hold particular promise for characteristics required for reduced-input turf applications. These characteristics include seedling establishment, production, and persistence of high quality turf under conditions of cold temperatures, low fertility, clipping, and other adverse conditions.

Objectives: The primary objective of our trip was to collect seed of grasses in genera of *Poa, Agrostis, Festuca, Koeleria,* and *Puccinellia,* which are known to have potential for reduced-maintenance turf applications. Another objective of our trip was to collect seed of various grass and legume species with potential for forage or conservation applications.

Logistical Arrangements: Dr. Vladimir Chapurin of VIR was the leader of our expedition. Dr. Chapurin has led and participated in more than 40 seed collection expeditions in Russia and Central Asia. He is a specialist in perennial forage legumes with an emphasis on red clover. This year's trip was conducted as part of a non-funded, five-year cooperative agreement that formalizes joint germplasm collection activities between VIR and ARS. Dr. Chapurin arranged with the VIR Foreign Relations Department (headed by Dr. Sergey Alexanian) for official invitation letters from the Russian Ministry of Foreign Affairs for obtaining my Russian visas. The morning after arriving in St. Petersburg, I registered with the Russian police for the necessary permission to travel for an extended period in Russia.

I brought along the necessary collecting equipment and supplies including seed envelopes, global positioning system (GPS), and other miscellaneous supplies. During the collection trip, the five expedition participants traveled in a four-wheel drive UAZ van and camped in tents. All food expenses were shared equally among participants. On returning to St. Petersburg, VIR provided lodging at one of their apartments located on Sapernyi Street. Procedures outlined in materials provided by Dr. Karen Williams were followed concerning seed export permits, Phytosanitary Certificate, and other importation documentation required for Homeland Security officials in the U.S.

<u>Collection Itinerary and Route (Figure 1)</u>

4-5 August 2007: I flew to St. Petersburg and was met at the St. Petersburg International Airport by Dr. Nickolai Dzyubenko (Director General of VIR) and Mr. Sergey Shuvalov of VIR's Department of Foreign Relations. We drove to VIR's apartments on Sapernyi Street in St. Petersburg. Prior to departing from the U.S., I purchased two MacAir Computers (with funding provided by benefit-sharing funds from the USDA Plant Exploration Fund). I presented these computers to Dr. Dzyubenko for use at VIR. These laptop computers will be used in processing collection passport data on VIR collecting expeditions. These will allow for easier and more accurate processing of passport data.

6 August: Dr. Dzyubenko picked me up, and I completed the necessary forms for an extended stay in Russia with the Russian police. I then changed currency and was taken to the St. Petersburg Airport for my four-hour flight to Orenburg. I was met at the Orenburg Airport by Drs. Vladimir Chapurin, Leonid Malyshev, and Tamara Buravtseva who had left St. Petersburg one week earlier to drive the collecting vehicle to the South Ural Mountains. We drove about two hours to our first campsite.

7-11 August: We began our collection trip in the southwestern portion of the Ural Mountains.

We made 55 collections of various grass and legume species along our route through the towns of Kumertau, Meleuz, and Ishimbay. Of particular interest were collections of species of *Poa, Festuca,* and *Agrostis*. Plant communities in this mountainous area represented an interesting mix of elements from the dry Kazakh steppe and European floras. Elevations at the collecting sites gradually increased from about 126 to 565 m during this portion of the collection trip.

12-15 August: We collected in forested areas south/southwest of Beloretsk. A total of 37 collections made in these areas with elevations ranging from 412 to 707 m. Plant communities in this area were dominated by pine/birch forests (*Pinus sylvestris*/*Betula pubescens*). Most collections were made in cleared areas, abandoned fields, hay-harvesting meadows, or power line corridors. Turf genera collected in this area included: *Agrostis, Festuca,* and *Poa.* Interesting collections of *Dactylis glomerata* were made, which may have adaptation for cold tolerance. A wide diversity of forage legume species were also collected in the following genera: *Trifolium*, *Vicia,* and *Lathyrus*.

16-22 August: We proceeded across to the eastern slope of the Ural Mountains from south/southwest of Magnitogorsk to Yuzhnoural'sk, Chelyabinsk, and Kyshtym. We descended in elevation from of 481 to 212 m. Collections of *Agrostis, Festuca,* and *Poa* continued to be made in hayfields, pastures, and on the margins of pine/birch forests. Particularly noteworthy was Site 31 (located about 33 km southwest of Ozersk), which contained an incredible diversity of grass and legume species. A total of 51 collections were made on this portion of the trip. It is interesting to note that Chelyabinsk was the city where the Russians developed their atomic bomb technology. This area has uranium deposits and because of security concerns was off-limits to all foreigners and most Russians during the Cold War Period.

23-25 August: We then crossed back to the western slope of the Ural Mountains and made 34 collections of various grass and legume species on our route through the towns of Satki, Duvan, and Karaidel. Elevations along this portion of the collecting route ranged from 256 to 596 m. This area was again dominated by birch/pine forests.

26 August: We descended down the western slopes of the Ural Mountains into the foothills and eventually rolling plains. These lower areas were heavily cropped with wheat. We made our last 7 collections mainly in shelter belts, flood plains, and field margins. When we reached Birsk, we stopped at the town museum. During World War II, the Ustimovskaya Research Station in the Ukraine (where Dr. Kir'yan, our Ukrainian team member works) had been relocated to Birsk to remove it from the threat of the German Army during 1941-1945 Dr. Kir'yan was interested in seeing what information might be available about his institute during those years. Unfortunately, all of the archives had been moved to Ufa so any information had to be obtained there.

27 August- Sept. 2: We drove seven 10-12 hour days to return to St. Petersburg. Our four-wheel drive vehicle had a maximum speed of about 85 km/hour (50 miles/hour) on roads that were heavily traveled by large, slow-moving semi-trailer trucks. As a result, progress was slow. In addition, the weather turned rainy and cold so camping was cold and damp. We were glad to get back to St. Petersburg. Dr. Kir'yan and I were dropped off at the VIR apartment building on

Saperyni Street. Accommodations were comfortable with a bathroom, bedroom, and sitting room. The room was equipped with a refrigerator and an electric pot for preparing basic meals. There was a small grocery store about a half block from the apartments with easy bus and subway access.

3-14 September: Collections were cataloged, dried, cleaned, and divided into portions for Russia, U.S., and Ukraine. Seed collections were delivered to the Federal Service for Veterinary and Phytosanitary Surveillance of the Russian Federation in St. Petersburg for inspection, a Phytosanitary Certificate was issued, and the collections were approved for export. The Ukrainian portion of the seed was hand-carried as luggage by train to the Ukraine by Dr. Victor Kir'yan. While in St. Petersburg, Dr. Elena Dzyubenko and I visited at the Komarov Botanical Institute with Professor Dr. N.N. Tzvelev, world renowned grass taxonomist. In discussing important centers of diversity for turfgrass species with Professor Tzvelev, he indicated that the Caucasus Mountain Region was one of the most diverse regions for grass species with high potential for reduced-input turfgrasses. After the visit with Dr. Tzvelev, we discussed a possible germplasm collection trip to the Caucasus Mountains of Russia with Dr. Nikolai Dzyubenko (Director General of VIR). He indicated that VIR would be interested in collaborating on such a collection expedition in 2010 or 2011. We also discussed a possible visit to the western U.S. for three VIR scientists in 2010.

15 September: I returned to the U.S. and delivered the U.S. portion of the seed collections to Homeland Security inspectors at the Salt Lake City International Airport. Our seed collections were sent to the USDA Plant Germplasm Quarantine Center in Beltsville, MD for inspection and processing. I was fortunate to return to Utah in time for the birth of our first grandchild on 25 September 2008.

Collections: Prior to our collection trip, only seven accessions of the targeted taxa were available in NPGS from the Ural Mountains. Our collection route traversed more than 6,000 km (Figure 1) and covered a diversity of plant communities in the South Ural Mountains. We brought back a total of 184 collections (Table 1) covering a wide range of grass and legume species from the Bashkortostan, Chelyabinsk, and Orenburg Oblasts of Russia. This included 41 collections of various species that hold promise for reduced-maintenance turf applications including *Poa* (23), *Festuca* (6), and *Agrostis* (12). Seeds of various forage grasses were collected and included *Bromus* (1), *Bromopsis* (2), *Festuca* (12), *Phalaroides* (1), and *Phleum* (7). Of particular note were collections of *Dactylis glomerata* (12), which may hold promise for cold tolerance. Opportunistic seed collections of various forage legumes were also made including *Lathyrus* (17), *Lotus* (1), *Medicago* (10), *Melilotus* (13), *Onobrychis* (6), *Trifolium* (35), and *Vicia* (12).

After processing of the seed collections at the Plant Quarantine Center in Beltsville, MD, our collections were shipped to Logan, UT where the seed was given a final cleaning. Small portions of the seed will remain at Logan for evaluation in breeding programs at the USDA-ARS Forage and Range Research Lab and Utah State University for their potential use in reduced-maintenance turf, forage, and conservation applications in the western U.S. The bulk of the U.S. portion of the seed will be sent to the Western Plant Introduction Station in Pullman, WA for incorporation into the U.S. National Plant Germplasm System where these collections will be available for research to scientists around the world. The Russian portion of the seed will be curated at VIR in St. Petersburg. The Ukrainian portion of the seed collection will be curated through the Ustimovskaya Research Station.

Benefits to U.S.: With the expanding human population in the U.S., demand for water is increasing for human consumption, recreational uses, landscaping, and industrial purposes. This is especially true in the western U.S. where water resources are limited due to low precipitation and high evaporative rates. Typical high-input turf species for expansive lawns, parks, and golf courses are becoming increasingly scrutinized for their water and maintenance costs. Water costs are continuing to increase, and water restrictions are being imposed during the hot, dry summer months in many metropolitan areas of the western U.S. As a result, homeowners, golf course managers, and park superintendents are actively looking for ways to reduce water consumption. Xeriscaping is becoming more and more popular and homeowners, park managers, and golf course superintendents are replacing high-input turf species with reduced-maintenance species.

Our collections will expand existing reduced-input turf germplasm by adding germplasm that has tolerance to clipping, low temperatures, and other adverse growing conditions. These collections may add important genetic diversity for response to clipping because plants there have been exposed to intensive grazing by wild and domesticated herbivores for thousands of years and have undergone natural selection so they are likely tolerant to clipping or mowing. As a result, germplasm from the South Ural Mountains of Russia holds promise for turf improvement programs. Collected materials also have potential for biotechnology applications to improve insect and disease resistance of important crop species. Incorporation of the collected germplasm into the NPGS will allow use by scientists in the U.S. and throughout the world, and will ensure preservation and conservation of this unique germplasm.

Benefits to Russia and Ukraine: Collections of reduced-input turf germplasm from the South Ural Mountain of Russia made on this trip will add important germplasm to the collections of the N.I. Vavilov Institute of Plant Industry (VIR), which is one of the world's premier institutions for curation of seeds of crop species and their wild relatives. These collections will make important germplasm available to Russian scientists in their breeding and improvement programs, which may eventually lead to improved cultivars for reduced-input turf. In addition, our collections will add important germplasm to the Ukrainian Genebank. Close interactions with botanists, forage scientists, and staff from VIR strengthened professional ties between U.S. and Russian scientists. Discussions among personnel during and after our collection trip allowed the exchange of the latest information concerning germplasm collection, preservation, and utilization. A possible forage genetics workshop was discussed for Russia, U.S., and China for October 2010.

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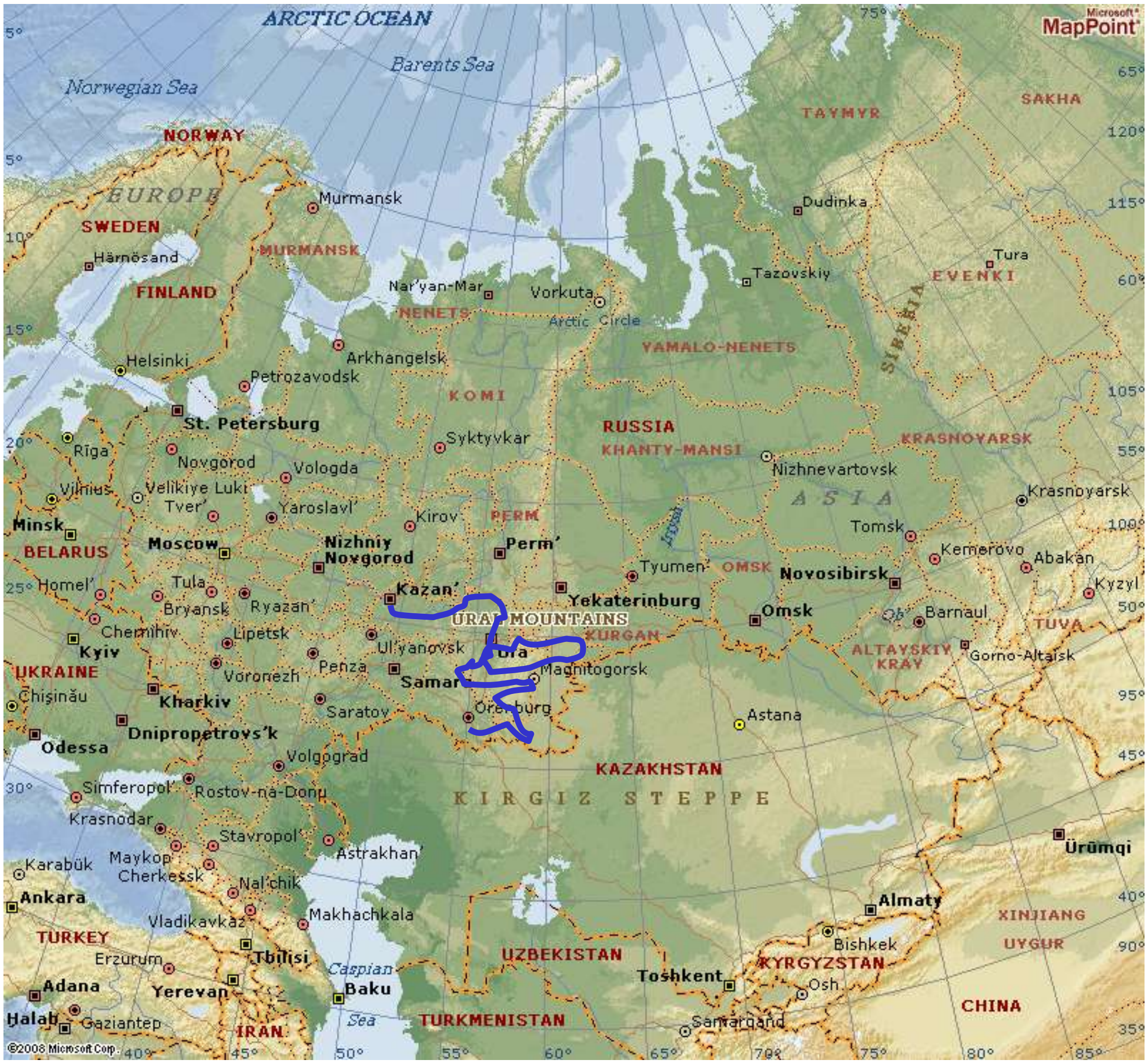

Figure 1. Collection route taken in the South Ural Mountains (2008).

Table 2. Species and numbers of collections made in South Ural Mountains (2008).

Agropyron pectinatum (2)	*Melilotus volgicus*
Agrostis gigantea (12)	*Onobrychis arenaria* (3)
Allium spp.	*Onobrychis tanaitica* (2)
Alopecurus arundinaceus (2)	*Onobrychis vicifolia*
Astragalus glycyphyllos (2)	*Phalaroides arundinacea*
Bromopsis erecta	*Phleum phleoides*
Bromopsis inermis (4)	*Phleum pratense* (7)
Bromus secalinus	*Poa angustifolia*
Dactylis glomerata (12)	*Poa compressa*
Elymus fibrosus	*Poa nemoralis*
Elytrigia repens	*Poa pratensis* (17)
Festuca orientalis	*Poa* spp.
Festuca pratensis (11)	*Poa stepposa*
Festuca rubra (5)	*Poa trivialis*
Festuca sulcata	*Rumex tianshanica*
Lathyrus pisiformis (2)	*Sanguisorba officinalis*
Lathyrus pratensis (8)	*Trifolium arvense*
Lathyrus rotundifolius	*Trifolium hybridum* (4)
Lathyrus sylvestris (2)	*Trifolium lupinaster* (2)
Lathyrus tuberosus (3)	*Trifolium medium* (6)
Lathyrus vernus	*Trifolium montanum* (6)
Lotus corniculatus	*Trifolium pretense* (15)
Medicago falcata (8)	*Trifolium repens*
Medicago lupulina (2)	*Vicia cracca* (7)
Melilotus albus (4)	*Vicia hirsuta* (2)
Melilotus officinalis (8)	*Vicia sepium* (3)

Total = 185