Realizing Value from Central Asian *Allium* Germplasm Collections

Philipp W. Simon[1]

U.S. Department of Agriculture, Agricultural Research Service, Vegetable Crops Research Unit, 1575 Linden Drive, Department of Horticulture, University of Wisconsin, Madison, WI 53706

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***Abstract*. Central Asia is the center of origin for many *Allium* species and a rich genetic source of wild relatives of onion and garlic. For this reason germplasm collections of cultivated *Alliums* have targeted the acquisition of seed and bulb samples from this region, and several plant expeditions from Asia, Europe, and North America have collected *Allium* germplasm in Central Asia. Central Asian *Allium* germplasm has been valuable both as raw materials for scientific research leading to published data, and as starting materials for genetic improvement of the crop. Utilizing this germplasm it has been possible to improve garlic so it can be bred like other seed-propagated crops. Several interspecific crosses have been made between onion and other Central Asian wild relatives and these crosses have yielded useful traits for onion improvement. *Allium* germplasm from this region has also been important in elucidating the systematics and origins of diversity in onion and garlic. By any of these measures, Central Asian *Allium* collections have been valuable. Challenges and successes in collecting, maintaining, evaluating, and using these collections remain.**

Plant germplasm is the basic building material used by plant breeders for crop improvement. The variation provided by diverse germplasm shapes the crops we grow today. In some cases breeders can point to the incorporation of specific original sources of valuable genetic variation that fundamentally changed a crop. In onion, for example, the discovery and characterization of cytoplasmic male sterility (CMS) in 'Italian Red 13-53' by Henry Jones in 1925 resulted in the transfer of this trait to most onion hybrids grown today (Jones and Clarke, 1943; Ryder, 2003; Simon et al., 1991). By using numerous and diverse sources of allelic variation, plant breeders have combined and recombined germplasm over time to change the genetic structure of onions, and of all crops. Often those diverse sources of allelic variation include traits from unadapted cultivated germplasm or wild related species. In this way, the plant germplasm collections maintained by national or international agencies, such as the extensive collections in the United States maintained by the USDA within the National Plant Germplasm System (NPGS), are reservoirs of traits essential to current and future crop improvement.

Healthy germplasm collections are not static, and targeted expansion of strategically important species or gene pools is an ongoing activity. The periodic expansion of plant germplasm collections has been undertaken by various individuals and organizations around the world. The appreciation of the central role that plant germplasm plays in sustaining crop improvement has fostered the development of Crop Germplasm Committees (CGCs) in the U.S. (Shands, 1995). While germplasm curators provide the extensive and intensive efforts necessary to maintain, increase, and distribute plant germplasm, about 40 CGCs comprise crop specialists from the public and private sector that provide general advice and oversight to NPGS curators.

Rationale and Opportunity for Exploration

One key function of CGCs is to encourage plant exploration to expand collections. In the 1980s, the Root and Bulb Vegetable CGC recommended that the NPGS *Allium* collection could benefit by the addition of more germplasm from Central Asia, since it is a center of diversity for many *Allium* species, including garlic and onion (Fritsch and Friesen, 2002). In the early 1980s there had been several expeditions to collect *Allium* germplasm in Central Asia by international teams, including local scientists collecting with German, Japanese, Polish, and other experts (e.g., Hong and Etoh, 1996; Kotlinska et al., 1991), but none from the U.S. However, through international political developments in the late 1980s, the outlook improved for another international expedition, this time including researchers from the U.S., to focus on collecting Central Asian *Allium*.

The rationale for collecting Central Asian *Allium* is straightforward. Onion germplasm had played a central role in broad-based improvement of the crop, including not only CMS for hybrid development, but also resistance to several diseases and improved storage quality (reviewed by Kik, 2002). Onion, *A. cepa* L., is not known to exist in the wild (Fritsch and Friesen, 2002) but its wild relatives and likely progenitor species occur in Central Asia, and small numbers of accessions were conserved by the world's genebanks. Similarly, wild garlic only occurs in Central Asia, yet the NPGS garlic collection in the 1980s included neither cultivated garlic, *A. sativum* L. from Central Asia, nor its purported wild progenitor, *A. longicuspis* Regel. In contrast to the appreciation held for onion germplasm and its role in improving that crop, garlic germplasm was only of limited value as a source of new clones. In spite of garlic being one of the oldest horticultural crops, routine production of garlic seed was unknown (reviewed by Etoh and Simon, 2002). Consequently, classical approaches to garlic improvement through plant breeding were impossible with the germplasm in the NPGS garlic collection of the 1980's. However, preliminary evidence suggested that garlic from Central Asia might harbor genetic diversity essential to improving one key trait of great importance: the potential for seed production (Etoh, 1986).

With this rationale and opportunity, in 1989 a proposal was made by the author, approved and funded by the USDA to collect wild *Allium* from the center of diversity of this valuable genus. The collecting team included *Allium* experts, Alexei Pimakov (Uzbekistan), Teresa Kotlinska (Poland), and a U.S. team consisting of Leonard Pike (Texas A&M University), *Allium* enthusiast John Swenson, and the author. Over a period of 3 weeks in the field, including Turkmenistan and Uzbekistan, the 1989 USSR *Allium* Expedition collected 83 *Allium* accessions (Table 1) along with 130 accessions of other genera which were shared among the Soviet, Polish, and U.S. teams. Included among the *Allium* accessions were collections representing 32 species (Table 1). Of the 83 *Allium* collections, 60 are now being conserved by the NPGS. This is a relatively high success rate in light of Dosmann and Del Tredici's (2003, 2004) discussion, and may be attributable to the specialized skills in *Allium* regeneration present within the NPGS. After regeneration, 482 seed or bulb samples have been distributed by the NPGS to researchers in the U.S. and 12 other countries (Richard Hannan, personal communication) (Table 1).

Value and Future Potential

Central Asian *Allium* germplasm has been valuable as raw materials for scientific research leading to new information and published data, as the starting material for the genetic improvement of onion and garlic, and for bringing new insights into the origins and development of these modern agricultural crops. Published research describing recent progress in developing a routine garlic-seed production system (Etoh et al., 1988; Hong and Etoh, 1996; Jenderek and Hannan, 2004; Pooler and Simon, 1994) points to the value of wild and cultivated germplasm from this region as a key component of its success. By observing the capacity for seed production in wild garlic from Central Asia, and then using the germplasm from collections made in that region, including *A. sativum* plant introduction 615416 and W6 entries 1861, 1862, and 1883–1885 we collected in 1989, it has been possible to improve garlic so it can be bred like any other seed-propagated crop today (Inaba et al., 1995; Jenderek, 1998; reviewed by Etoh and Simon, 2002; and

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[1]To whom reprint requests should be addressed; e-mail psimon@wisc.edu.

Table 1. *Allium* accessions collected in Central Asia by the 1989 USSR *Allium* Expedition, their availability and distribution within the U.S. National Plant Germplasm System.

Species	Accessions collected (no.)	Accessions conserved in NPGS (2004) (no.)	Seed and bulb samples distributed (1989 to August 2003) (no.)
Allium aflatunense B. Fedtsch.	2	2	19
Allium altissimum Regel	1	0	0
Allium barsczewskii Lipsky	1	1	1
Allium baschkyzylsaicum Krassovsk.	1	0	0
Allium caeruleum Pall.	2	1	8
Allium caesium Schrenk	4	4	25
Allium cepa L.	4	1	0
Allium collis-magni Kamelin	1	0	0
Allium costatovaginatum Kamelin & Levichev	1	1	1
Allium cristophii Trautv.	2	0	0
Allium drepanophyllum Vved.	1	1	0
Allium ericoleum Vved.	1	1	2
Allium giganteum Regel	2	2	0
Allium jodanthum Vved.	3	3	7
Allium karataviense Regel	1	1	2
Allium kokanicum Regel	1	0	0
Allium longicuspis Regel	3	3	73
Allium monadelphum Less. ex Kunth	1	1	3
Allium motor Kamelin & Levichev	3	3	2
Allium oreophilum C.A. Mey.	1	1	3
Allium praemixtum Vved.	1	0	0
Allium pskemense B. Fedtsch.	1	0	1
Allium ramosum L.	1	0	0
Allium regelii Trautv.	1	0	1
Allium rubellum M. Bieb.	1	1	0
Allium sativum L.	9	8	273
Allium scabriscapum Boiss. & Kotschy	2	1	6
Allium sewertzowii Regel	1	0	1
Allium sp.	23	19	27
Allium stipitatum Regel	4	4	24
Allium talassicum Regel	2	1	1
Allium vavilovii Popov & Vved.	1	0	2
Total	83	60	482

Simon and Jenderek, 2003). Published research documenting the extensive breadth of *A. sativum* diversity has also confirmed that Central Asia is a major reservoir of that diversity (Etoh et al., 2001; Ipek et al. 2003; Maaß and Klaas, 1995; Pooler and Simon, 1993). These studies have been valuable in changing our thinking about the relationship between cultivated and wild garlic to suggest that cultivated garlic is a subset of wild garlic brought into cultivation over history, rather than a separate species (Etoh and Simon, 2002; and Simon and Jenderek, 2003).

Other Central Asian *Allium* collections have also been useful in providing information to broaden our understanding of the genus, and in providing allelic variation useful for breeders improving the onion crop for agriculture production. Over the last 70 years, several interspecific crosses have been made between onion and its Central Asian wild relatives, including *A. altaicum* Pall.*, A. fistulosum* L.*, A. galanthum* Kar. & Kir.*, A. oschaninii* O. Fedtsch.*, A. pskemense* B. Fedtsch., *A. roylei* Stearn, and *A. vavilovii* Popov & Vved. (reviewed by Kik, 2002). These crosses have yielded useful traits for onion improvement, including male sterility, bulbing response, and resistance to several diseases, including anthracnose, downy mildew, leaf blight, and pink root (de Vries et al., 1992a, 1992b; Emsweller and Jones, 1935; Galvan et al., 1997; Havey, 1999; McCollum, 1971; Peffley and Hou, 2000; Yamashita et al., 1999). They have also been important in elucidating the systematics and domestication of onion, and the basis of its genetic diversity (reviewed by Fritsch and Friesen, 2002).

The value of central Asian *Allium* germplasm is only beginning to be realized. Basic research across the globe uses this germplasm in several ongoing studies to understanding general diversity and floral development in this diverse genus (Ipek et al., 2003; Kamenetsky et al., 2004a, 2004b), and *Allium* breeders continue to find new useful traits to incorporate into the garlic and onion crops, such as CMS and compounds beneficial to human health (Kik, 2002). As *Allium* germplasm is collected more extensively from the diverse environments of Central Asia, the prospects remains high for the realization even more value from genetic diversity useful for improving consumer quality and crop resistance to biotic and abiotic stresses.

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