(continued from previous page)
encountered problems remain the requirements for import permits and/or for additional declarations calling for growing season field inspection of parental plants to certify to the absence of special disease organisms in the grow-out area, region, or country. More and more curators are arranging to have their fields inspected regularly, but it will be some time before all grow out areas will have instituted these inspections. Until such time as all of our fields are regularly inspected we will have to endure the delays encountered when shipments cannot meet importing countries' requirements.

Dissemination of information on plant germplasm exchange was accomplished in several ways. PIO staff traveled overseas to Haiti and the Dominican Republic in September 1990, and contacts with Bulgaria from the previous year have resulted in a very successful forage exploration in that country by two U.S. university scientists. Articles published in journals, and other germplasm-related media, and reports to committees and others within the scientific community have generated much interest in germplasm exchange. Personal contacts with the many visiting foreign scientists who pass through PIO and other sites have helped ensure continued exchange of valuable plant germplasm.

Profile: The Inter-Regional Potato Introduction Project (IR-1), U.S. Center for Potato Germplasm

by David M. Spooner and John B. Bamberg

History and Current Status of IR-1

Maintenance and preliminary evaluation of the great variety and large amount of *Solanum tuberosum* L. cultivars and wild species are beyond the resources of individual potato breeders and would be, in any case, a needless duplication of effort (see box). In 1947 the Potato Association of America made an appeal for a potato germplasm center which led to a cooperative United States/North-Central Regional program in 1948. Since 1950, the project has been a cooperative program of the four U.S. Department of Agriculture (USDA) Experimental Regions and the federal government, and is designated as the Inter-Regional Potato Introduction Project (IR-1).

The project is responsible for the introduction, preservation, classification, distribution, and preliminary evaluation of the germplasm of tuber-bearing *Solanum* species. The general policies and direction of IR-1 are developed by a Technical Committee consisting of representatives from the four USDA Experimental Regions, a representative from the USDA, Agricultural Research Service (ARS), a representative from Agriculture Canada, the project leader, a member of the USDA-ARS National Program Staff, the USDA Cooperative State Research Service (CSRS), and the Interregional Administrative Advisory Committee composed of one director from each region. Funding is provided by CSRS and ARS. The University of Wisconsin Research Station donates facilities and pays for utilities.

Botanist David M. Spooner and Geneticist John B. Bamberg are associated with the Vegetable Crops Research Unit, United States Department of Agriculture, Agricultural Research Service. Both hold appointments as Assistant Professor, Department of Horticulture, University of Wisconsin-Madison.

Solanum bulbocastanum, *a wild Mexican-Guatemalan potato having many natural disease resistances.* (Photo courtesy of D.M. Spooner)

Facilities and Operations

Major IR-1 facilities are located at the University of Wisconsin Peninsular Agricultural Research Station at Sturgeon Bay, Wisconsin. Project facilities include a fireproof building housing seed and tuber processing and storage space. This is complemented by a laboratory for tissue culture services and research, nine greenhouse compartments and 10 screenhouses providing space for propagation of germplasm increase and research plantings, and 12 acres of field plots that the research station use each year for evaluation and research plantings.

Dr. John Bamberg, USDA-ARS, leads the project and conducts research on germplasm techniques, genetics of valuable traits found in wild species, and evaluation of crossability systems and techniques. Chief researcher Dr. Robert E. Hanneman, Jr., USDA-ARS studies haploids, 2n gametes, and EBN for germplasm enhancement. Max Martin, Administrative Project Assistant, is in charge of *in vitro* and virus testing. Dr. David M. Spooner, USDA-ARS is investigating a combination of traditional systematic approaches using computer-assisted morphological studies, field studies, and DNA studies utilizing chloroplast and nuclear DNA. In addition, he collects germplasm and maintains the herbarium of plants collected in the field and those cultivated at Sturgeon Bay. The germplasm collection consists of over 4,000 seed and 600 clonal accessions some of it collected by the world's leading potato scientists (see DIVERSITY, vol.7,nos.1& 2,p.46).

The project enjoys the benefits of cooperation with several agencies. The USDA-ARS provides salaries and research funds for Bamberg, Hannemann, and Spooner. Although the main operating budget is provided by the USDA-CSRS, significant cooperation and support is provided by the University of Wisconsin Research Station in the form of facilities and utilities. Funds for disease screening have been provided by USDA-ARS, and USDA-CSRS.

IR-1 makes every effort to be "user-oriented" and in touch with its clientele. On-site research on IR-1 stocks by visiting foreign and domestic scientists have greatly contributed to those interactions that enable IR-1 to serve its international role in a broader way than by simply providing germplasm. These contacts enable IR-1 personnel to provide useful advice and information on choice of materials and techniques for other research programs.

Germplasm Collections

In addition, over the past 30 years, more than 35 potato collecting expeditions have been conducted by various international organizations. Seeds and tubers of these collections have been sent to IR-1* (Hanneman and Bamberg, 1986). (For a detailed report of these collecting expeditions written by Dr. Spooner, see DIVERSITY, vol.7,nos.1&2, p.46.)

Failsafe devices and backup samples serve as effective strategies to ensure the continued availability of the germplasm.

Despite these expeditions, there still are large gaps remaining in the world's holdings of wild potato germplasm. Of the 222 species listed in Hawkes (1990), IR-1 has only 120, and Hawkes documents only 128 species represented in the world's potato genebanks. The species at IR-1 have greater numbers of collections for some species than for others (e.g. *S. acaule* with 371 accessions, or *S. tuberosum* ssp. *andigena* with 708). Eighty percent of IR-1's accessions are distributed among nine percent of the species in the collection, and eighteen percent of the collection's species are represented by one to five accessions (Spooner, 1990). Some species, even those with high numbers of accessions, have been collected over only a fraction of their total range. Because most species are highly variable, and because this variability may be partitioned geographically, additional collections are needed.

Maintenance and Distribution

Scientists for IR-1 and elsewhere have developed efficient methods for propagating and preserving the introduced *Solanum* accessions. These methods, now part of the station's routine, include efficient means for increasing seed through hand pollination in greenhouses and screenhouses during spring, summer, and early fall. Mechanical devices for pollen collection and handling, and for seed extraction have expedited propagation. Failsafe devices and backup samples serve as effective strategies to ensure the continued availability of the germplasm. One of the challenges IR-1 must meet is to develop improved technical efficiency. This will allow for continued distribution of quality potato germplasm despite the growing collection.

Most accessions are preserved as botanical seeds, as they are easier to maintain in a disease-free state, require less labor and materials for storage and shipping, contain

*The other major genebanks for potatoes include: Instituto Nacional de Tecnología y Agropecuaria, Balcarce, Argentina; Universidad Austral de Chile, Valdivia, Chile; Colección Central Colombiana, Bogota, Colombia; Institut für Pflanzenbau und Pflanzenzüchtung, Federal Republic of Germany; Landwirtschaftswissenschaften, Gross-Lusewitz, Federal Republic of German; Centro Internacional de Papa, Lima, Peru; Commonwealth Potato Collection, Dundee, Scotland, UK; and N.I. Vavilov Institute of Plant Industry, Leningrad, USSR (Hawkes, 1990).

The Riches of *Solanum*

The major potato of commerce, *Solanum tuberosum* L., is the fourth most important food crop in the world after rice, wheat and corn. The potato yields one and one-half times as much food value per acre and provides twice as many calories and more protein per acre than cereal crops. Potato protein is nutritionally as good or better than soybean protein and exceeds the nutritive value of grains or legumes (Anon., 1979). It is grown in more countries than any other crop but corn, and forms the staple crop of many societies. Over 350 million metric tons were grown worldwide in 1988, with about one-quarter grown in the Soviet Union, one-seventh in China, and one-eighth in Poland. In the United States it is the leading vegetable crop in acreage and farm value. Although the United States grows only one twentieth of the world's production, the value of sales there was almost $2 billion in 1988 (National Potato Council, 1990).

Wild Potato Diversity

Solanum tuberosum is one species of a group of seven cultivated, and over 200 additional tuber-bearing and a few non-tuber-bearing wild relatives, all classified in the genus *Solanum* section *Petota*. This diverse group of plants is distributed from the southwestern United States to southern Chile. The latest taxonomic treatment (Hawkes, 1990) partitions this diversity into 21 taxonomic series, the largest of which, ser. *Tuberosa*, contains *S.tuberosum* and 93 other wild and cultivated species. There is tremendous morphological and physiological diversity in the group. Although most plants are terrestrial, one species, *S. morelliforme*, is epiphytic. Tubers vary in size, from that of a pea to nearly the size of the cultivars, and in taste, from edible and flavorful to bitter and actually toxic. Plant habits vary between species from ground-hugging rosettes to upright plants well over 1-1/2 meters tall. Leaf margins vary from entire to highly dissected, with leaf lobes relatively wide to almost linear. Most species are devoid of glands while some are highly glandular. Corolla shapes vary from circular to star-shaped, ranging in color from white to pink to purple (yellow in the tomato-like series Juglandifolia); fruits vary in shape from globose to elongated.

Disease Resistances

These wild species and primitive cultivars harbor a tremendous diversity of natural resistances to commercially important diseases or environmental stresses. Resistances are known to viral, fungal, or bacterial pathogens, nematode and insect pests, as well as resistances to heat, cold, and drought (Hanneman, 1989; Hanneman and Bamberg, 1986; Hawkes, 1990; Huaman, 1983). Much of these data have been obtained through contractual agreements between IR-1 and cooperating scientists. The IR-1 inventory (Hanneman and Bamberg, 1986) lists accession-specific screening data obtained from the literature or through informal communications with IR-1 cooperators.

Ease of Using This Germplasm

The potato is unsurpassed among crop plants with this abundance of related wild germplasm. Fortunately, it usually is very easy to obtain interspecific hybrids through sexual crosses, sometimes between morphologically very dissimilar species, and these hybrids often are fully fertile or with little reduction in fertility. Some species, however, are separated by strong crossing barriers involving a little-understood process governed by ratios of maternal/paternal genomes in the endosperm. Despite these difficulties of sexual gene transfer between commercial cultivars and most wild species at different ploidy and EBN levels, it is still possible to use these wild species by means of chromosome manipulations involving haploids, 2n gametes, EBN numbers, and bridging species (Barsby et al., 1984, Chavez et al., 1988; Ehlenfeldt and Hanneman, 1984; Peloquin et al., 1989). Additionally, somatic fusion hybrids have succeeded in combining the germplasm of some species with wide crossing barriers (Austin and Helgeson, 1987; Barsby et al., 1984; Fish et al., 1988).

Use of Wild Species and Primitive Cultivars

These wild species and primitive landraces have been successfully used for potato breeding. For example, Ross (1986) showed that 97 European cultivars contain genes from wild species and two primitive Andean cultivars. Plaisted and Hoopes (1989) have documented the parentage of North American cultivars, citing the importance both of wild species and the cultivars *S. phureja*, *S. tuberosum* ssp. *andigena* and ssp. *tuberosum*. The following 15 wild species have entered into the parentage of European and North American cultivars: *S. acaule*, *S. chacoense*, *S. commersonii*, *S. demissum*, *S. fendleri*, *S. kurtzianum*, *S. maglia*, *S. microdontum*, *S. raphanifolium*, *S. sparsipilum*, *S. spegazzinni*, *S. stoloniferum*, *S. toralapanum*, *S. vernei* and *S. verrucosum*. Although *S. demissum*, a hexaploid Mexican species with late blight resistance, has been widely used, other wild species have conferred resistances to a variety of the viral, fungal, and bacterial diseases, or the nematode and insect pests of potatoes. Wild species and primitive cultivars have improved valuable agronomic traits such as yield, specific gravity, chipping qualities, and suppression of enzymatic browning. Current research is discovering the disease resistance and improved horticultural trait genes present in many other wild species, and this list is sure to increase.

For a list of these references, contact authors.

greater genetic diversity, and have a much greater longevity than vegetative propagules (tubers and *in vitro* shoot tips). Botanical seeds generally require one year of testing in quarantine (at Glenn Dale, Maryland) before they are received at Sturgeon Bay. Two to three years then pass before general distribution. During this time, the accession is increased, taxonomically determined, indexed for systemic seedborne viroid (PSTV) and assigned plant inventory (PI) numbers. More than 90 percent of the stocks in the collection are maintained as true seed.

Clonal stocks such as foreign varieties, breeding and genetic stocks are received after approximately two years in quarantine. *In vitro* culture of shoot tips has been added to IR-1's capabilities to maintain clonal stocks in a disease-free state. New clones are placed *in vitro*, tested for viruses and PSTV, and placed on storage medium at 10°C. Subcultures are prepared as these stocks are requested.

The germplasm supplied by IR-1 has proven to be valuable not only to breeders but also for basic research.

IR-1's scope with respect to potato germplasm is truly global. Requests for *Solanum* germplasm and the resulting data have steadily grown since the Project's establishment. Since 1980, 1,385 orders containing 71,504 accessions have been distributed by IR-1. For each clonal accession requested, IR-1 typically ships two to four *in vitro* plantlets.** Scientists are encouraged to request as many stocks as they can profitably use. The only "payment" requested in return is that cooperators inform IR-1 of any evaluation results (specifying PI numbers) which may be of interest to future requesters, as well as resulting publications.

The germplasm supplied by IR-1 has proven to be valuable not only to breeders but also for basic research. Since 1950, IR-1 has supplied germplasm used in programs resulting in more than 1,100 published research papers on the biochemistry, cytogenetics, entomology, food science, genetics, horticulture, nematology, pathology, physiology, and taxonomy of *Solanum* sect. *Petota*. These stocks have been used in nearly 175 programs for completed masters and doctoral theses.

**Printed or electronic inventories, screening data, and germplasm stocks may be obtained by sending a written request to John Bamberg, Potato Introduction Station, 4310 Highway 42, Sturgeon Bay, WI 54235, USA. Business hours are from 7:30-4:30 CST Monday through Friday for those who wish to make a request by telephone (414-743-5406). International requests should check with their governments and include documentation, special instructions, or permits which may be required by the receiving country.

International Collaboration

The international scope of potato localities, collections, scientific research, and germplasm storage makes international collaboration and cooperation a necessity and a great opportunity, especially in the evolving dialogue of international concerns over the ownership of genetic resources (see DIVERSITY, vol.5,pp.59-60). IR-1 has greatly benefitted from the generous contributions of many national and international collaborators. The facilities at IR-1 have been visited more than 100 times by international scientists since its inception.

The USDA has funded collecting trips to the southwestern United States (1978), Mexico (1982,83,84,88), Argentina (1983, 90), Bolivia (1986,87), and Chile (1989). Field-trip planning and germplasm collecting is done with the full collaboration of in-country scientists associated either with government organizations (as in Argentina, Mexico, Bolivia) or universities (as in Chile). Field trip costs are paid by the United States, and all germplasm and herbarium materials are equally divided before leaving the country.

IR-1 has greatly benefitted from the taxonomic expertise of various scientists. During the last 33 years IR-1 has funded the following visits by the world's foremost experts to the station for taxonomic identification of the collection: Donovan Correll (1955,59,60), Jack Hawkes (1958,65,69,71,73,78,84,86,87,89), J. Peter Hjerting (1958,72,86), Zósimo Huamán (1970,84), Luis López (1970), Carlos Ochoa (1967,69,77,78,83,87), Katsuo Okada (1973,77,81,85,86), T. Richard Tarn (1982,83,84,85,86) and Donald Ugent (1967, 68,75). Data obtained by these visits have been used in publications of these scientists and the identifications have been incorporated into the IR-1 inventory.

Focus on Taxonomy and Collecting

In 1987, David Spooner was hired as the new taxonomist for IR-1 to provide in-house taxonomic expertise and new germplasm collections. Collaborative reports or studies from these collecting trips include the following: the collecting report from the Mexico-1988 trip has been completed (Spooner et al., 1991), as well as the collecting report from the Chile-1989 trip (Spooner et al 1991). Similar publications are in preparation for Ecuador and Argentina, in collaboration with Andrea Clausen for Argentina, and Raul Castillo and Luis López for Ecuador, respectively.

Spooner was invited by Andres Contreras and his colleague, Luigi Ciampi, to assist on a 1990 expedition to collect *S. tuberosum* ssp. *tuberosum* in the Chonos and Guaitecas Archipelagos in southern Chile with funding provided by the Instituto L'Otremare de Firenze, Italy. Spooner and Contreras are working on a taxonomic revision of *Solanum* ser. *Etuberosa*, and are working with David Douches at Michigan State University on isozyme studies of this group. Andrea Clausen and Spooner have begun DNA reinvestigations of a taxonomic question on *S.* x *rechei*, an Argentine potato species.

In 1988 and 1989, Spooner worked with Aaron Rodríguez at Sturgeon Bay on taxonomic studies resulting from the 1989 Mexico trip, as well as with Ronald van den Berg of the Wageningen Agricultural University (1989,90,91). Bamberg and Spooner recently worked with Raul Castillo, head of Germplasm Resources at the Instituto Nacional de Investigaciones Agropecuarias, to plan collaborative potato collecting expeditions to Ecuador in 1991 and to Colombia and Venezuela in 1992.

In the face of increasing population pressure and the tragic rapid destruction of many of our natural habitats, the world's genebanks are continuing to increase in importance. International cooperation is an absolute necessity for the continued growth and maintenance of these tremendous international resources. IR-1 remains committed to continue to serve the global community and to maintain mutually productive international relationships.

For additional information, contact: Dr. David M. Spooner or Dr. John Bamberg, Dept. of Horticulture, University of Wisconsin-Madison, 1575 Linden Drive, Madison, WI 53706, USA. Tel: (608) 262-0159. FAX: 608-262-4743.

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