

# Potato Improvement Using **EXotic**

By Dr. Shelley Jansky, USDA-ARS and UW-Madison



Dr. Shelley Jansky is shown with tubers from three seedlings that were produced by crossing a cultivated clone with a wild species plant.

With over 100 wild related species at their disposal, potato breeders have access to a tremendous amount of genetic diversity for cultivar improvement. Wild species are found in a diverse array of environments, including the cold high grasslands of the Andes, hot semi-desert habitats, humid subtropical mountain rain forests, cultivated fields, and even as epiphytes in trees. These wild species contain genes with encoding traits not found in cultivars and represent an especially rich source of disease resistance and tuber quality genes.

The major cultivars planted in the US today contain only a small amount of exotic germplasm introduced by potato breeders for genetic improvement. Of course, nearly half of the US acreage is planted to Russet Burbank, a clone that was developed well before modern breeding programs were in place. A quick scan of the pedigrees of current major cultivars reveals common parents such as Chippewa, Katahdin, Early Gem, Ontario, Irish Cobbler, Earliane, Hindenberg, Jubel, and Russet Burbank (<http://www.plantbreeding.wur.nl/potatopedigree/>). These parents were used in potato breeding programs in the mid- twentieth century because they consistently produced adapted offspring with acceptable yields. However, in recent years, potato breeders have become interested in wild relatives of potato as sources of traits not found in traditional breeding program parents. Historically, especially in Europe, wild species have been used as sources of disease resistance. However, they are also becoming increasingly important for their contributions to processing and culinary quality.

In the 1930's, the wild species *Solanum demissum* was found to have resistance to late blight. Late blight resistant *S. demissum*-derived germplasm was devel-

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# Germplasm: Prospects and Challenges

oped by the USDA in the 1930's and is found in the pedigrees of many cultivars developed in subsequent decades, including Cherokee, Early Gem, Kennebec, Merrimack, Onaway, Saco and Superior. The major resistance genes in *S. demissum* provided good protection against late blight until the 1960's, when genetic changes in the pathogen allowed it to overcome host plant resistance. Current breeding efforts are focusing on more durable forms of late blight resistance. For example, the pedigrees of the new cultivars Jacqueline Lee, Missaukee, and Defender contain diverse wild species as sources of late blight resistance. In another disease resistance example, resistance to PVY, PVX and golden nematode has been introduced from *Andigena*, a cultivated relative, into the cultivar Eva.

The wild species *S. chacoense* has made important contributions to processing quality in potato cultivars. *Solanum chacoense* is a grandparent of the cultivar Lenape, which, in turn is in the pedigrees of several processing cultivars, including Atlantic, Gemchip, Snowden, Belchip, and Spartan Pearl, as well as the purple-skinned cultivar Michigan Purple. Lenape has exceptionally high specific gravity, which presumably contributes to its superiority as a parent for the production of processing clones. Another wild relative, *S. tarijense* (= *S. berthaultii*) is a good source of chip quality, especially at cold storage temperatures. It is a parent of S440, a breeding clone in the pedigrees of White Pearl (which also contains Lenape) and Kalkaska. S440 and its full-sib, S438, are parents of several advanced selections in the Wisconsin breeding program, including W2133-1, W2310-3, W2717-5, and W2324-1.

With increasing interest in culinary quality, breeders will likely be turning to exotic germplasm for traits not found in

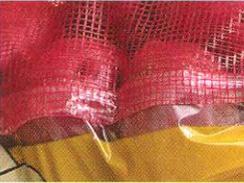
standard cultivars. South American land races, derived from many sources, including a cultivated group called Phureja,

contribute red, yellow, and purple flesh as well as unusual patterns of flesh and skin  
*Continued on pg. 18*










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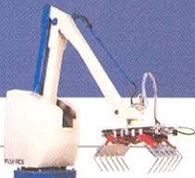
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*continued from pg. 17*

colors. These colors provide unique offerings on dinner plates, but they also add to nutritional quality by contributing to antioxidant activity. Yukon Gold can credit its yellow flesh to Phureja in its pedigree. The Scottish Crop Research Institute has found that Phureja-derived germplasm has exceptional flavor and shortened cooking times compared to standard cultivars. Although the new Phureja cultivars Mayan Gold, Inca Sun and Inca Dawn are lower yielding than conventional cultivars, they are being promoted as niche-market clones.

Late blight and PVY resistance genes have been reported in 14 and 6 wild *Solanum* species, respectively. Similarly, resistance to other major diseases and improved processing quality traits have been reported in dozens of wild *Solanum* species. Why have only a handful of these species found their way into the pedigrees of potato cultivars? First of all, except for the post-Irish potato famine era, there has not been a strong perceived need for the introgression of exotic germplasm to reduce losses to disease. For the first half of the twentieth century, yield was the principal goal of breeding programs. Standard cultivars and breeding lines provided yield variability, and experience working with those clones provided breeders with a feel for the most effective cross combinations. However, intercrosses among a limited set of parental clones resulted in a high degree of relatedness among the cultivars that were developed. Consequently, substantial yield gains were not realized as a result of breeding efforts in the mid-1900's. In addition, the dramatic increase in processed potato consumption in the last half of the century required breeders to find superior germplasm for specific gravity and processing color. Finally, an increasing interest in alternatives to chemical disease and pest control has led to a search for sources of host plant resistance. In recent decades, it has become apparent to breeders that genetic diversity from new sources is needed for continued progress in cultivar development.

With the realization of the need to increase genetic diversity, it has become

necessary to develop strategies to introgress wild germplasm into breeding programs. The US Potato Genebank (NRSP-6) holds 5,681 populations of 131 *Solanum* species. Agronomically important traits have been identified in many of these species. Using straightforward methods to overcome crossing barriers, over half of these species can be crossed to the cultivated potato. The offspring segregate for adaptation to north temperate photoperiods, but typically at least half tuberize in the field. In addition to contributing specific genes for economically important traits, wild relatives provide the genetic diversity necessary for hybrid vigor. It is interesting to note that hybrids between the cultivated potato and several wild species produce tubers that look "normal" even though they are 50% wild. Other wild and cultivated relatives, though, produce hybrids with rough tubers, so extensive backcrossing efforts are necessary to produce acceptable tubers. Other challenges associated with

the use of wild germplasm include male (and sometimes female) sterility, the production of glycoalkaloids, and linkage between genes for traits of interest and those for adaptation. These can be overcome with the careful selection of germplasm and breeding methods.

Because potato breeding is a time- and cost-intensive endeavor, varietal breeders can not devote substantial resources to the search for useful genetic diversity and its incorporation into their parental lines. Instead, two USDA breeding programs (C. Brown, Prosser, WA and S. Jansky, Madison, WI) are charged with germplasm enhancement. These programs serve as the interface between NRSP-6 and US potato breeders. Our mission is to develop parents to be used by breeders for cultivar development. Ideally, these parents contribute new economically important traits, while simultaneously adding genetic diversity and consequently hybrid vigor to potato breeding programs. ♦

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