Potato Breeding With Wild Species

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Throughout the twentieth century, plant breeders have made remarkable progress in improving potatoes for both the producer and consumer. However, the genetic diversity available in the cultivated potato is becoming increasingly narrow as a result of intensive breeding and selection among a set of elite parents. As the demands of farmers and the public increase and become more complex, potato breeders must expand the base of usable germplasm in their programs in order to meet their needs.

Wild potato species germplasm offers a seemingly unlimited source of genetic variability. While this resource has been used somewhat in the past, efforts to systematically incorporate it into breeding programs in the United States have been minimal. Recently, though, many breeders throughout the country have been taking a serious interest in the utilization of exotic *Solanum* germplasm.

Wild potato species are found throughout areas of Central and South America. Because they survive in a diverse range of environments, they contain many valuable traits, such as drought and frost tolerance, disease and insect resistance, and tuber storage quality. A large collection of wild species is available to breeders through the IR-1 Potato Introduction Station at Sturgeon Bay, Wisconsin. This collection has been screened for various traits, making it possible for breeders to select accessions that will be valuable for their particular interests.

While the wild potato species may make positive contributions to breeding programs, there are some problems which must be overcome. First of all, most wild species have two sets of chromosomes, rather than the four sets found in potato cultivars. Fortunately, chromosome number is usually relatively easy to manipulate in the potato, and is done routinely in our program. Secondly, wild species require a short daylength before they produce tubers. In other words, they are late-maturing. This problem is overcome to some extent when wild species are crossed to the cultivated potato.

Our program focuses on two aspects of wild potato species utilization: development of breeding methods and incorporation of valuable traits.

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DEVELOPMENT OF BREEDING METHODS

New methodologies must be developed and tested if wild species are to be efficiently incorporated into breeding programs. Ploidy (chromosome number) manipulations must be an integral component of these procedures.

In order to cross wild species with two sets of chromosomes (2x) to potato cultivars with four sets (4x), two approaches may be applied. First, the chromosome number of the wild species may be doubled. This can be accomplished through the use of 2n gametes (pollen grains or egg cells with twice the normal chromosome numbers), chemical treatment, tissue culture, or somatic fusion (combining two cells, each with two sets of chromosomes). Alternatively, the chromosome number of the cultivated potato can be reduced by one-half to produce haploids which are 2x. This can be accomplished through a cross which induces development of haploid seeds or through tissue culture of pollen or egg cells. We are currently studying the efficiency of these various approaches.

The other consideration when working with wild species is vine maturity. Our program recently completed a study on whether it is effective to select wild species populations for early maturity before crossing to haploids of cultivars. Our conclusion was that selection of wild species is generally ineffective. The haploids are apparently so effective in inducing early maturity in hybrids with wild species that they mask differences in the species parents.

We are also looking at the effectiveness of breeding at the diploid (2x) level versus the tetraploid (4x) level. Genetic studies are much more complicated with tetraploids than diploids. Consequently, experimental results are more accurate and genetic gains are more rapid in diploids. Working at the diploid level also forces pairing of chromosomes from wild species with those of cultivars. This should allow genes from wild species to be transferred into adapted germplasm. However, it appears that genes are not as readily moved as we initially believed. We are currently using starch gel electrophoresis to evaluate this situation and determine whether our methods must be modified.

We have been developing 2x hybrids between haploids and wild species. However, potatoes perform best at the 4x level, so we must transfer these hybrids into 4x cultivars. Before we put much effort into the development of superior 2x hybrids with wild species, it is critical to know how effectively our selected traits are transferred to the 4x level. Traits such as tuber eye depth and vine maturity are transferred effectively, while traits with a more complicated genetic basis, such as yield, are not correlated between the 2x and 4x levels. We must establish the effectiveness of transfer to the 4x level for every trait we develop at the 2x level.

TRANSFER OF SPECIFIC TRAITS

Our main trait of interest to date has been resistance to the Colorado potato beetle (CPB). The CPB is the major defoliator in potato and is becoming increasingly difficult to control. Because the CPB has become a serious pest in recent years, our emphasis is directed toward its control.

Wild potato species possess two known types of resistance to the CPB. Sticky hairs, or glandular trichomes, on the leaves are effective in entrapping CPB larvae until they starve to death. The hairs, however, are not effective against adults. In addition, natural chemicals in leaves of some wild species can deter feeding by CPB. Recently, a chemical called leptine has been identified in one wild species. It is ideal, because it is found in leaves but not tubers. We can, therefore, increase its level without affecting tuber palatability.

Jim Mooney, a graduate student in our breeding program has developed 2x clones with high levels of CPB resistance due to glandular trichomes. These lines are somewhat adapted because they contain cultivar haploids. Our next goal is to combine them with high leptine clones. We have tried crossing them but have had no success, so our next effort will be to utilize protoplast fusion. We will combine a cell from a trichome clone with one from a leptine clone to produce a hybrid with all the chromosomes from both parents. These hybrids should be 4x and, therefore, crossable with advanced 4x selections in the potato breeding program.

There are a number of questions we are attempting to answer in our attempts to breed for CPB resistance: Are there other mechanisms of resistance in wild species? Will combining glandular hairs with leptines provide a durable form of resistance? Can the CPB overcome resistance in the wild species as is it has done with pesticides? Can effective resistance be combined with good tuber quality? This last question will determine whether our ultimate goal can be achieved. We believe that CPB resistant, high quality cultiars can be developed, but not without a considerable input of research effort.

Another graduate student, Vergel Concibido, is beginning a project to incorporate Verticillium wilt resistance into breeding material. The pathogen responsible for this disease is prevalent in the Red River Valley and is involved in the early dying complex. High levels of resistance have been identified in several wild species. We intend to carry out genetic studies at the diploid (2x) level and then look at the transfer of resistance to the tetraploid (4x) level.

Bacterial ring rot (BRR) is another serious concern for potato growers. Seed lots are rejected from certification if any level of the disease is detected. Many cultivars readily express symptoms of BRR while others may be symptomless carriers. Currently, susceptible cultivars are preferable because they allow for accurate disease detection. However, it would be ideal to produce cultivars with immunity to BRR. These clones would be able to exclude the pathogen, so they would express resistance without being symptomless carriers. In cooperation with the plant pathology department, we are screening wild species for BRR immunity. Preliminary results indicate that immunity may indeed be found in some wild species. If this is true, then we will try to transfer the trait into cultivated germplasm.

Although breeding methods must be developed in order to effectively use wild potato species, the effort is justified. In addition to contributing genes for resistance to serious pests and diseases, they appear to improve vigor and environmental stability of the cultivated potato. It appears that, in the future, utilization of wild species will become an integral component of many potato breeding programs.