Biotechnology: Applications to Potato Breeding

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The goal of the potato breeding program at NDSU is to develop superior quality, high yielding and well-adapted cultivars for the Red River Valley and other potato growing regions. The progress of the program relies on traditional breeding techniques and a germplasm base of highly selected material. However, advances in biotechnology which are applicable and available to this program are utilized to enhance productivity.

Somatic fusion hybrids of a wild potato species *S. brevidens* (non-tuber-bearing) and *S. tuberosum* (the cultivated potato) are being grown in the Red River Valley for the first time as part of a co-operative project with Dr. John Helgeson of the University of Wisconsin plant pathology department. The hybrids, produced through fusions of single cells from each of the parents, were made to incorporate the potato leaf roll virus (PLRV) resistance of *S. brevidens* into materials which would be cultivar-compatible. The hybrids are remarkably vigorous and most express PLRV resistance, but because they have a wild species parent they diverge substantially from standard varietal type; yields are lower, tubers are misshapen, and many hybrids have a late maturity. Fortunately many of the hybrids are fertile and can cross readily with varieties.

Since all hybrids in a given fusion derive from the same two parents, studies are intially focusing on evaluation of the range of variation for tuber traits seen among hybrids. Two potential sources of variation exist. One is the variation seen naturally in any materials coming out of tissue culture and referred to as somaclonal variation, the second is variation due to the wild species germplasm. Since *S. brevidens* is non-tuber bearing, it is uncertain what effects, if any, it exerts on tuber quality. It may alter tuber characteristics dramatically or only slightly. This research will get at both of these sources of variation by examining both fusion hybrids and tissue-culture regenerated plants of the variety parent. Specific gravity, reducing sugar, total sugar, tuber dormancy, and glycoalkaloids will be examined.

Besides determining the effects of *S. brevidens* germplasm and the quantative nature of somaclonal variation, this evaluation will be a good evaluation of the performance of these materials in our environment. This material possesses PLRV resistance and serendiptiously has been found to possess excellent *Erwinia* rot resistance. The best lines from this evaluation will be incorporated into the NDSU breeding program to transfer these traits to upcoming varieties.

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Two graduate students are beginning studies of directed variation in tissue-culture-derived plants. These studies will evaluate changes induced through both chromosome loss and chemical alteration of DNA structure, and will evaluate the utility and heritability of variants arising from these treatments.

A major effort is being made to incorporate new sources of wild species germplasm into advanced potato breeding lines. Exotic potato species such as *S. commersonii*, *S. cardiophyllum*, *S. berthaultii*, *S. chacoense* and *S. tarijense* are being used to introduce improved characters into varieties. *S. commersonii*, a South American species, possesses high specific gravity and tolerance to both frost and heat. *S. cardiophyllum* possesses yielding ability and attractive smooth tubers.

Unconventional techniques are being employed to incorporate these materials. *S. commersonii* and *S. cardiophyllum* require that their chromosome numbers be doubled simply to cross with diploids. This initial set of crosses yields triploids. These triploids present problems because of their extremely low fertility. A second round of chromosome doubling, or alternatively selection for types producing pollen with double the normal number of chromosomes is required to cross these materials to varieties.

Interspecific *Solanum* hybrids are also being produced to introduce resistance to Colorado potato beetle and green peach aphid. Each of the wild species, *S. neocradenasii*, *S. berthaultii*, *S. tarijense*, *S. chacoense*, *S. bulbocastanum*, *S. brachistotrichum*, *S. brevidens*, *S. jamesii*, and *S. trifidum*, possesses resistance to either or both insect pests. Before hybrids are produced, haploids of the cultivated potato must be developed. These haploids contain half as many chromosomes as their cultivar parents, but they have the same number as the wild species. Most wild species cross directly to these haploids. However, as with *S. cardiophyllum* and *S. commersonii*, the chromosome complement of some of these wild species must be doubled before hybridization is successful. A meiotic mutant has been used to effect hybridization and gene transfer into this situation. Preliminary results indicate that some of the potatoes carrying genes from wild species express a high level of resistance to the pests under consideration. The next steps are to evaluate horticultural quality of the tubers and continue to add resistance genes to promising selections.

One potential problem that may develop as a result of extensive utilization of exotic germplasm is an increase in glycoalkaloids in potato tubers. Glycoalkaloids are found in all potatoes, but they may exist in very high levels in some wild species. A high level of glycoalkaloids results in bitter, sometimes inedible tubers. Consequently, this breeding program must identify a method to screen large numbers of samples for glycoalkaloid content. The method of choice appears to be an ELISA (enzyme-linked immunosorbent assay) procedure for total glycoalkaloids. This procedure utilizes an antiserum that is specific for glycoalkaloids found in potatoes. It is sensitive, specific, and produces an end point that can be quantified and analyzed using a microplate reader. The ELISA system is also used to detect the prescence of viruses in seed potatoes.

Another tool which has the potential to significantly impact our research is starch gel electrophoresis. Electrophoresis is a procedure which enables analysis of direct gene products without interference from environmental or genetic interactions. We are currently equipping an electrophoresis laboratory to study genetic variability in wild and cultivated potatoes. We will also study genetic crossing-over, which is involved in gene transfer between species.

In the future, efforts will concentrate on improving the efficiency of gene transfer from wild potato species and screening for desirable traits. One procedure which will be studied in this regard is gamete selection. Pollen grains are known to express a large number of genes that are also expressed at the whole plant (sporophytic) level. By subjecting pollen grains to stress, such as cold temperature or high salinity, it is possible to develop highly selected populations before crosses are even made. Similarly, *in vitro* selection of single cells may be used to identify somatic variability that will result in stress tolerance. Of course, this method is effective only if the whole plant utilizes cellular, rather than tissue- or organ-level, tolerance mechanisms.

The potato breeding project at NDSU is involved with many aspects of genetics and selection. The significance of biotechnology research for this program is that it provides methods to improve the efficiency and accuracy of our research. The combination of plant breeding techniques with the tools of biotechnology will help to ensure the success of this program in the future.