GENETIC IMPROVEMENT OF POTATO USING TRADITIONAL BREEDING AND GENE TECHNOLOGY

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INTRODUCTION

New varieties of potato have the potential of solving many of the production problems of present-day potato production if the traits incorporated are properly chosen. The problem the breeder faces is to determine if genetic variation exists that can impact problems and if this variation can be incorporated into new varieties. The tools available have been expanded in recent years. While most potato breeding still involves crossing and selection, new traits can be introduced by gene insertion techniques. The purpose of this essay is to explore potato breeding in the modern landscape where traditional methods are increasingly being combined with gene technology.

Traditional Breeding

Traditional breeding creates new genetic variation by sexual reproduction of potato. This involves making crosses and starting new clones from seedlings that emerge from true seed. Traits are usually freely available in cultivars, advanced breeding clones, and primitive sources, such as highly unadapted native cultivars from the center of origin, or wild potatoes. The introduction of most traits is inhibited only by the difficulty of obtaining the desired expression of characters that have low heritability and appear at low frequencies at an optimal level of expression in breeding populations. In other words, potato is hard to breed. The rarity of combinations of certain characters means that many seedlings must be examined in order to end up with a successful variety. One variety might be selected out of a million seedlings. Extremely successful varieties that change the face of potato production occur perhaps in one out of 50 million seedlings on a worldwide basis.

Following is a list of characters that are obtained by crossing potato clones with each other:

1. Yield
2. Tuber size
3. Tuber shape

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4. Skin type and color
5. Flesh color
6. Solids
7. Maturity
8. Tuber dormancy
9. Resistance to internal defects, (hollow heart, internal brown spot, stem end necrosis, sugar end, bruising, shattering)
10. Light fry color out of 48°C or colder storage temperatures
11. Scab resistance
12. Verticillium resistance
13. Erwinia soft rot resistance
14. Resistance to viruses (PVX, PVY, PLRV (stunting and net necrosis))
15. Resistance to nematodes (Meloidogyne, Globodera)

The above list is by no means exhaustive, but it is obvious that incorporation of very important characters into potato is still largely the province of sexual breeding.

Gene technology

Research into gene technology has opened up several opportunities for the practical breeder. Genes from any organism, from chickens to viruses, can be incorporated into and expressed in the potato plant. This means, for example, that toxins expressed in the plant might be utilized instead of chemicals applied to foliage or soil to control pests or pathogens. In addition, plant products or products of animal or microbial metabolism, never expressed before in potato, might be synthesized in potato. It should be pointed out, however, that there is still considerable need for testing of the various traits as they are expressed in plants grown under commercial growing conditions. Many novel results are possible to achieve, which contributes to a sense of limitless potential and also some unease on the part of the public. However, there are relatively few research areas of immediate interest to the "potato as a food" industry. Following is a list of some gene technology projects that are currently being researched:

1. Resistance to viruses (coat protein, antisense, untranslatable RNA)
2. Resistance to insects (Bt toxin genes)
3. Resistance bacteria (cecropin, chicken lysozyme)
4. Starch genes (amylose-free mutant, high starch)

The nature of gene insertion requires some qualification and comment. First, the breeder will benefit from the ability, in certain cases, to insert a new trait into an already good clone.

The most important principle here is accessibility of traits not available before in potato germplasm. The breeder will welcome, secondarily, that cloned genes will be sexually transmitted as single genes. Expression is likely to be reasonably constant in one-half to five-sixths of the progeny for simplex and duplex breeding parents, respectively. As mentioned before, the probability of finding superior clones combining many good traits is dauntingly low in traditional breeding. The prospect of improving a such rare finds by addition of a single trait by sexual means is also bleak, even with the intrusion of biotechnology. The highly heterozygous nature of potato clones combined with the low heritability of many traits are difficult barriers.

While the improvement of the good breeding clones or variety with gene insertion is an interesting opportunity for the public researcher, the real change that this has engendered is in the promulgation of venture capital for potato variety development. The long tradition of public breeding of potato varieties has meant that clones that can serve as receptacles for patented genes are themselves public property. A potato variety with an inserted gene, that is well-expressed, is sure to be different from the parent clones, and very likely to be an improvement that can be sold as a differentiated product. The patentability of cloned genes seems to be an attractive investment when used to augment the performance of a potato variety, which can be potentially planted on thousands of acres every year. One needs to exercise caution at all stages, however. The solution of a single insect pest problem, for example, by gene insertion may be conceived of as a dramatic and beneficial change. Often times insects that were previously controlled by an insecticide targeting another species become significant pests when this form of control is discontinued. If this happens, then the desired result of genetic engineering, i.e. in this case reduced use of insecticide, may not materialize. Genetic engineering that produces highly specific changes may have destabilizing influences on the ecology of the agricultural environment. Research is needed on a case by case basis.

CONCLUSION

Although the advent of biotechnology in potato variety development has opened up new vistas, the core development of new genotypes will remain traditionally based. The most important characters are obtainable only from crosses between potato clones and relatives. It is likely that the first impact from gene technology will be, however, in pest and disease control. The demand for this, as a substitute for application of chemicals to plant and environment is very high and it appears that the debut of potatoes with genetically engineered pest/disease resistance will be timely.