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Hybrid Corn

Practical benefits from plant biotechnology have not matched expectations that were raised a decade or more ago. The lack of benefits has in part been due to blockages by government regulations. But perhaps the major reason is that plant genomes are complex and insertion of a gene or a few genes will not necessarily produce a superior variety of broad applicability. An example of the extent of the challenge can be seen in hybrid corn. This cultivar has been a major target. The market for hybrid corn seed in the United States alone totals more than $2 billion a year.

The corn genome contains about 20,000 genes. Of these, at least 30 genes located on unknown positions on the chromosomes influence yield. Actual yield is governed by many other factors. Through the use of hybrid techniques conventional breeders have succeeded in developing plants that can endure many vicissitudes while producing superior yields. Limiting factors vary from place to place. For example, in the humid southeast United States a particular hazard is viral disease. In other areas the problem may be periodic droughts. In Minnesota the short length of the growing season requires a fast-maturing variety. In other areas the best yields are obtained from slower maturing hybrids. In heavy clay soils there is root rot. Almost everywhere there is the European corn borer. High-yielding tall corn can be blown over during storms. Strengths of stalks and roots is important. New pathogens appear. Mutant varieties of older ones arise.

The various hazards can be minimized through breeding. The successful commercial corn breeder must provide hybrids optimized to the varying hazards and circumstances of the differing localities. Competition to meet these needs is intense, and several hundred different variants of seeds are available in any given year. Each year new improved seeds are introduced. In 1989 Pioneer Hi-bred International alone released 24 different hybrids optimized to meet local conditions.

Since 1928, yields of corn have been improved by a factor of about 5. Part of the increase has been due to use of fertilizer. At least half has been due to the use of hybrids, and their improvement continues with no end yet in sight. Production of commercial hybrid seeds involves a long-term, painstaking effort. First, inbred lines possessing desired traits are created through at least six generations of inbreeding. This process requires a minimum of two years with some of the generations grown outside the corn belt. Subsequently, the inbred lines are crossed to produce tens of thousands of different hybrids. Their seeds are tested on tens of thousands of experimental plots. About one in 2000 of the hybrids will be identified as a superior strain. Further tests follow, and ultimately the successful hybrids are grown in commercial amounts. Normally 10 to 15 years have been required to create a new improved hybrid and to produce seed from it in commercial quantities.

The impacts of biotechnology on corn breeding have been limited to date. Thus far, it has been possible to introduce one gene at a time, but the result has not been dramatic. Perhaps the most important accomplishment has been to incorporate resistance to certain herbicides. Plants, including weeds, synthesize some of their amino acids by pathways different from those of animals. The plant pathways can be inhibited by very small amounts of biodegradable herbicides. Corn hybrids have been created that are resistant to those herbicides. There is uncertainty as to when the federal regulators will provide the necessary approvals for widespread use of bioengineered variants of corn. Extensive testing is required to guarantee that the introduction of new genes has not impaired performance in other respects.

Two molecular biology methods are finding increased use in plant biotechnology. Diagnostic kits that use the polymerase chain reaction (PCR) to detect viruses in plants are now widely available. Biotechnology has provided plant breeders with an important tool of restriction fragment length polymorphism (RFLP). Restriction enzymes are used to cut the plant chromosomes into fragments. Comparisons of the fragments from various hybrids can help identify areas of the plant chromosomes that are important in determining agronomic traits such as drought resistance. Use of RFLP also has potential importance in legal problems and in the creation of effective patents. One has the impression that RFLP will speed the rate of improvement of hybrid corn, but it will not outmode many of the procedures of plant breeders.—PHILIP H. ABELSON