Corn Transformed

Researchers have achieved a long-sought goal: the production of fertile corn plants bearing functioning "foreign" genes

A STRANGE NEW CORN VARIETY, unknown in the annals of agriculture, is growing in a suburban Connecticut greenhouse. Researchers at DeKalb Plant Genetics in Groton have produced fertile corn transformed with a foreign gene that makes the plants resistant to the herbicide bialaphos. This achievement, published in the July issue of *The Plant Cell*, is the first report of fertile transgenic corn in the reviewed literature, and it is the capstone of almost a decade's efforts to genetically engineer this country's most important crop. The only other major crop to be so manipulated is rice.

The ability to produce transgenic corn gives biologists a valuable tool to probe the whys and hows of gene expression and regulation. It may also give plant breeders a way to develop new corn varieties with a speed and predictability that would be impossible with classical breeding techniques.

The race to develop transgenic corn has been intense. Last January, researchers at Biotechnica, Inc., in Minnetonka, Minnesota, announced that they had got there first. But their results, which were publicized in the *Wall Street Journal*, have not been submitted to peer review, and the company has yet to provide details of the methods used or the genes they inserted. As a result, there has been considerable skepticism about the work—especially in light of the years of frustration plant scientists have endured trying to overcome two formidable obstacles.

First, researchers had to find a way to get novel genes into plant cells, and then, using cell culture techniques, they had to coax the transformed cells into regenerating into whole, fertile plants. In 1983, they appeared to be well on the way when groups at Monsanto in St. Louis, the Max Planck Institute in Cologne, and the State University in Ghent showed that a modified plasmid from the pathogen *Agrobacterium tumefaciens* could act as a vector, transferring foreign DNA into plants. However, they still faced a "monocot barrier": The *Agrobacterium* vector that easily transferred DNA into dicotyledonous plants, such as tobacco and petunia, failed to work with the monocots, which include all the valuable cereals.

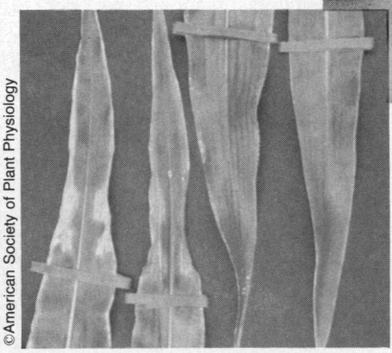
After several years of frustration, a second round of efforts yielded more promising ways of getting foreign genes into cereals. In 1988, for example, Carol Rhodes and her colleagues at Sandoz Crop Protection in Palo Alto, California, transformed corn by applying a jolt of electricity to puncture self-repairing holes in corn protoplasts, which are plant cells stripped of their cell wall. The technique, called electroporation, allowed them to insert foreign DNA, and they regenerated the transformed protoplasts into plants. But celebrations were short-lived: the resulting plants were infertile.

Yet another step toward the goal of producing fertile transgenic corn was taken last year. Maro Söndahl of DNA Plant Technology in Cinnaminson, New Jersey, and a second team led by Christian Harms of CIBA-Geigy in Research Triangle Park, North Carolina, appeared to have solved this latest problem when they developed cell culture techniques for regenerating ordinary corn protoplasts into fertile plants. But these techniques, so far, have not worked with genetically transformed corn.

So, the DeKalb team's announcement that they have neatly sidestepped both problems comes as quite a victory. They used a gene gun (see *Science*, 22 June, p. 2493) to propel genes directly into whole cells, shooting them through the box-like cell wall. "Basically, we bomb the corn cells with the gun," says Catherine J. Mackey, leader of the DeKalb team. The gun, she says, shoots metallic microprojectiles coated with DNA that codes for an enzyme that endows corn with herbicide resistance. It appears to be the only satisfactory technique for transforming whole cells of monocots, and these transformed cells are amenable to cell culture procedures.

The DeKalb work, says Nam Hai Chua of the Rockefeller University, "is a significant achievement because it puts all the bits together"—and to the satisfaction of the scientific community. Indeed, the success of this general scheme for transforming and regenerating corn cells has already been confirmed by a U.S. Department of Agriculture team at the Plant Gene Expression Center in Albany, California, led by Michael Fromm, who has recently left the center to work at Monsanto. The USDA data will be published in September in *Biotechnology*.

DeKalb's candor in openly and swiftly announcing the details of its transformation work is becoming increasingly rare in plant biology, where commercial opportunities are evident with many experiments. Many research teams, especially those in smaller companies, are pressured to protect the proprietary rights of their work and defer publishing. That's the reason the Biotechnica team's work appeared first in the *Wall Street Journal* rather than a peer-reviewed journal.



Fertile minds. *The DeKalb group (right) produced fertile corn carrying foreign genes. Leaves from the transformed plants (below right) are resistant to the herbicide bialaphos.*

Says Biotechnica team leader Roger Kleese: "We are the little guy. We can't afford to tell the competition, such as DeKalb, the details of what we have done." Kleese says Biotechnica has filed for a U.S. patent on its procedure, and that it plans to publish its results soon after filing for a European patent, probably sometime early in 1991. Only then will it become clear whether the DeKalb team was truly the first to engineer fertile corn or whether Biotechnica deserves that credit. ■ ANNE SIMON MOFFAT

ADDITIONAL READING

W. Gordon-Kamm *et. al.*, "Transformation of maize cells and regeneration of fertile transgenic plants," *Plant Cell* **2**, 603 (1990).

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