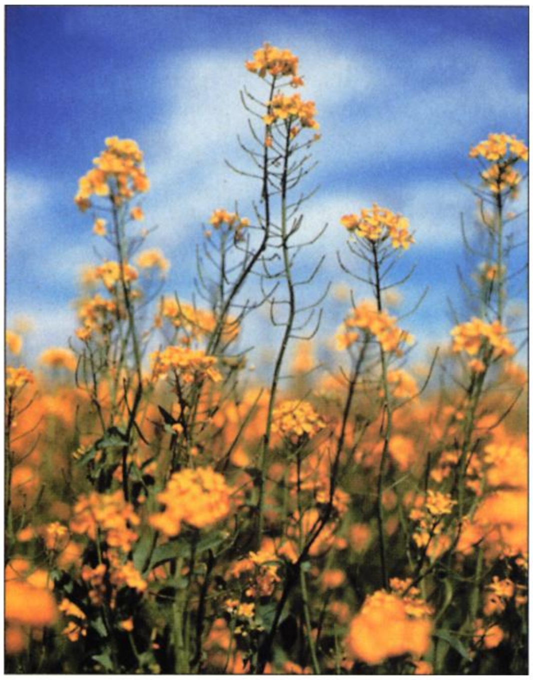
MEETING AGRICULTURAL BIOTECHNOLOGY INTERNATIONAL CONFERENCE

Biotech Research Proves a Draw in Canada

TORONTO, CANADA—Despite protests from Greenpeace members, some of whom dressed up as "corn fakes" to show their opposition to genetically modified organisms, more than 500 industrial and academic researchers, lawyers, and business people from about 25 countries gathered here from 5 to 8 June for the third biennial Agricultural Biotechnology International Conference. Highlights of the meeting included reports of progress toward making plants that resist nematode pests or stresses such as salt, frost, and drought.

Making Plants More Stress Tolerant

As farmers know all too well, drought or an unexpected cold snap can play havoc with their harvests. Indeed, drought and frost intolerance, together with intolerance to salt—a growing problem thanks to irrigation, which leads to salt accumulation in the soil—are the three major problems that restrict the growth of plants worldwide. Now, researchers are beginning to make progress in developing new strains of crop plants more capable of withstanding these stresses.



Golden targets. With the right genetic manipulation, canola plants such as these may better withstand cold, salt, and drought.

At the meeting, plant molecular geneticist Michael Thomashow of Michigan State University in East Lansing described work by his team indicating that a relatively simple genetic alteration—the introduction of a single gene involved in controlling the synthesis of certain protective compounds—into canola plants can improve both their frost and salt tolerance. "This is a very sound approach that is going to be useful," predicts Cornell University plant biochemist Ray Wu.

Thomashow's result is an outgrowth of findings made over the past 10 years in several labs, including his own and that of the husband-wife team of Kazuo Shinozaki and Kazuko Yamaguchi-Shinozaki at the Japan International Research Center for Agricultural Science in Tsukuba. The work has shown that some plants can acclimate to cold, drought, and salt—all of which ultimately exert their deleterious effects by dehydrating cells—by generating a variety of enzymes that cells use to produce chemicals and proteins that can protect against dehydration. More recently, the researchers identified a small family of transcription factor proteins that turn on the genes needed to make the protective compounds. This suggested that genetically altering plants to make more of the transcription factors could improve their tolerance to drought, salt, and freezing—an idea that was subsequently borne out in gene transfer experiments on the small plant *Arabidopsis thaliana*.

In experiments done 2 years ago, for example, the Thomashow team linked the gene for a transcription factor they identified to a regulatory sequence that promotes its activity and then introduced this hybrid gene into *Arabidopsis* plants. They found that the altered plants could survive temperatures 3°C colder than those tolerated by unaltered plants. Later that year, the Shinozakis showed that two different transcription factors identified by their team trigger tolerance to drought and salt loading, as well as to freezing, in *Arabidopsis*. But as Thomashow points out, "This work was in *Arabidopsis*. The challenge is to extend these findings to a real crop."

That's what the Thomashow team has now done in canola, an oilseed crop closely related to *Arabidopsis*. The researchers introduced each of the three transcription factor genes individually into canola plants. They obtained similar results with all of the resulting plants. At least under growth-chamber conditions, the plants showed improved freezing tolerance ranging from 2°C for plants that had not yet been exposed to cold temperatures, to 6° for plants that had already been acclimated by exposure to cold. Although a 1° or 2° improvement might be useful, Thomashow says, a 6° improvement would be significant.

And further improvements may be on the way. Cornell University low-temperature expert Peter Steponkus, who has worked with both Thomashow and the Shinozakis, has recently transformed *Arabidopsis* plants with one of the Shinozakis' transcription factor genes. "It is a real winner, maximizing freezing tolerance up to 10°C," he says. In contrast, he found only a 1° improvement using the gene that gave a 3° improvement in the Thomashow team's *Arabidopsis* experiments.

The reason for that discrepancy is currently unclear, and in any event, it's likely that researchers will have to tinker with the gene constructs they are introducing into plants to get maximal improvements in tolerance to cold and other stresses. They will also have to show that the genetic manipulations that work in lab and greenhouse conditions will work in crops planted in the field. But if all goes well, farmers may worry less about drought or an unexpected freeze nipping their crops in the bud, a real threat as floral parts are among a plant's most sensitive organs.

New Nematode Protection?

Each year, tiny but voracious nematode worms cause $78 billion in worldwide crop losses. Now, scientists are hoping to thwart these rapacious pests by a clever trick: manipulating the cell cycle of the plants they feed on.

At the meeting, plant molecular biologist Dirk Inze of the University of Ghent in Belgium and the agbiotech company CropDesign NV near Ghent reported that a genetic manipulation that blocks the cell cycle in plant roots invaded by a nematode prevents this pest from killing the plant. The findings open the door to developing new strains of nematode-resistant plants, which would be a major advance given the amount of crop destruction these worms cause. "Nematodes are a huge problem, and

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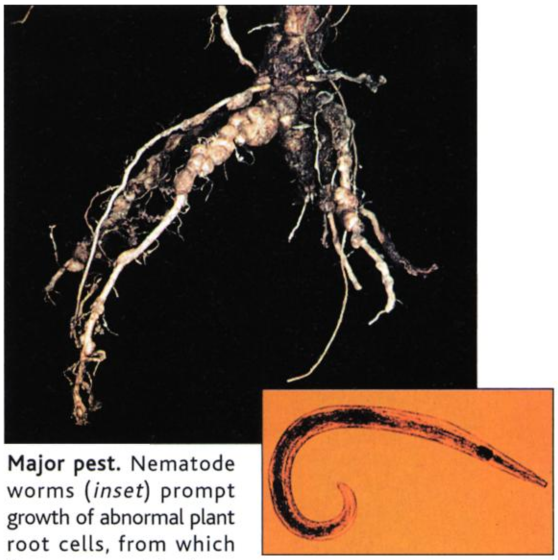
available nematocides are environmentally undesirable compounds," says plant scientist Chris Lamb, director of the John Innes Centre in Norwich, U.K. Using cell cycle disrupters to upset nematode feeding "is a new and interesting idea," he adds, although he cautions that it's still "untested."

When the tiny worms invade the roots of plants, they trigger the formation of either tumorlike growths called "galls," which contain large, multinucleated cells with dense cytoplasm and numerous mitochondria, or syncytia, large collections of cells that have fused. Either way, the nematodes feed on these abnormal cells, sucking out nutrients for themselves and severely damaging or killing the plant. Apparently, the worms trigger the formation of these abnormal cells by turning on a variety of plant genes, including some needed to drive the cell cycle. About a year ago, Inze and his colleagues showed that cell cycle inhibitors can prevent the formation of the multinucleated cells or syncytia—a change that could deprive nematodes of their preferred feeding grounds.

The Belgian workers have now performed a genetic manipulation on the small experimental plant *Arabidopsis* that essentially tricks invading nematodes into turning on a cell cycle blocker. The researchers had previously identified a gene regulatory element called a promoter that is activated in plant cells by nematode feeding. This leads to activation of the cell cycle and other genes needed to induce gall or syncytium formation. Inze and his colleagues have coupled this promoter to a gene that produces a kinase enzyme known to inhibit the cell cycle. When this hybrid gene was introduced into *Arabidopsis*, the cell cycle arrested specifically in the parts of the roots invaded by nematodes, preventing the formation of the large feeding cells. The nematodes could not feed anymore, and the plants became free of nematode infection.

So far, Inze says, "cell cycle studies in plants are in the early stages." Researchers will need to show that similar genetic manipulations can be achieved in crop plants. But Inze predicts that the work has the potential to produce plants resistant to nematodes and other pests and pathogens. "Plant development is quite plastic," he notes. "It can be managed."

—ANNE SIMON MOFFAT



Major pest. Nematode worms (*inset*) prompt growth of abnormal plant root cells, from which they remove nutrients.

EARTH-MONITORING SATELLITES

Will the U.S. Bring Down The Curtain on Landsat?

Researchers are fawning over improved images from the new Landsat 7 satellite. But they also worry that there may not be a suitable successor to the government-built spacecraft

Last month a small group of earth scientists got their first detailed look at data from a $700 million U.S. earth-monitoring satellite. It was a knockout. Landsat 7, launched in April 1999, was performing far above expectations, producing detailed images of forests, volcanoes, ice sheets, and other signs of global changes. "This is the finest terrestrial observatory we have ever flown," crowed Sam Goward, a geologist at the University of Maryland, College Park.

Their delight, however, was tempered by a big concern: Landsat 7 could be the last of a line of satellites first launched in 1972. Although the craft is scheduled to operate until at least 2006, there's already a struggle under way to decide who—if anyone—should build and operate a successor, at a cost of at least $400 million. That decision will shape the future of Landsat's 27-year-old data archive, which has been used for everything from monitoring desertification to identifying growing suburbs ripe for new fast-food outlets.

Private companies say they are the rightful heirs to the earth-sensing throne, and they want the government to get out of the burgeoning imaging business. But many researchers worry that science will suffer if private companies call the shots. They want the federal government to remain in charge, perhaps as part of an international consortium. "The question is how to make a transition without jeopardizing the [extension of the] largest existing land-observation data set in the world," says Donald Lauer of the U.S. Geological Survey (USGS) in Sioux Falls, South Dakota.

An eye on change

While other earth-sensing satellites are focused on the oceans or atmosphere, Landsat keeps an eye on terra firma. The 4-meter-long, 2200-kilogram current model, for instance, carries sensors that collect data in eight wavelengths of visible and infrared radiation, producing snapshots that cover 183-km-by-170-km patches of ground. The images, which allow researchers to identify different kinds of soil, vegetation, and land uses, detail objects down to 30 meters across and feed a community that ranges from military planners to geologists. Although new commercial satellites have much finer resolution—down to 1 meter—Landsat's broader view "is more appropriate for studying large-scale changes," says earth scientist Curtis Woodcock of Boston University (BU). And because Landsat 7 returns to the same spots every 16 days and follows paths blazed by older siblings, researchers can monitor changes over time scales ranging from weeks to decades.

The Landsat archive's value for tracking long-term landscape changes was highlighted at a recent meeting in Boulder, Colorado, of the satellite's science team, a group of 14 investigators funded by NASA and USGS. Woodcock, for instance, documented the growing holes that loggers have carved into Oregon's old-growth forests over the past 15 years (see images). Geologist Alexander Goetz of the University of Colorado, Boulder, has quantified the vast expansion of pivot-arm irrigation—in which a long sprinkler arm turns around a central pivot, like the spoke of a wheel—over the same period in a 1-million-square-kilometer arid patch of the western United States. The irrigation pattern could influence how ancient sand dunes in the area behave if an extended drought strikes, or when farmers exhaust groundwater supplies. "We're trying to develop a model that will tell us if we're going to get a dust bowl, or something even worse," he says.

The improved performance of Landsat 7's Enhanced Thematic Mapper Plus (ETM+)—its primary instrument—was the focus of other researchers. David Skole of Michigan

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