Biotechnology Takes Root in the Third World

The new technology offers the hope of increasing crop yields in areas where population growth is outstripping the food supply

THE HIGHLANDS OF COMMUNIST VIETnam seem an unlikely spot for a thriving biotechnology venture. But in this rustic setting, in a small town called Dalat, members of 30 families are helping to prove that biotechnology can be useful—and even profitable—to developing nations.

For several years the families have been reaping profits from crops of potato plants they've grown with the tools of biotechnology. With an average investment of $250, these farmers have set up makeshift laboratories in their backyards and bedrooms where they use tissue culture techniques to propagate potato plants from tissue ordered from the International Potato Center (CIP) in Peru. Their potato progeny earn the families $100 to $120 a month—a considerable sum in rural Vietnam—and some of the farmers are starting to use the same techniques to propagate other vegetables in vitro.

It's what CIP biochemist John Dodds calls "backyard biotechnology," and he says that scenes like this are becoming more common as biotechnology techniques are trickling down to farmers in developing countries. "It's a stunning example of how you can apply what most people think of as a sophisticated technique in a simple way," says Dodds, head of genetics for CIP. "Here I walk into this guy's bedroom, and he is using tissue culture in an exceedingly efficient way." The visit proved to him that biotechnology could be beneficial in developing nations, and now CIP is showing other farmers in countries from Indonesia to Ecuador how to adapt the same methods.

Biologists have long claimed that the Third World agriculture has much to gain from biotechnology. And the numbers attest to the countries' great need to increase their crop yields. In the next 10 years, the world's population is expected to grow from 5 billion to 6 billion, mostly in developing nations where millions of subsistence farmers already are having trouble eking out an existence on depleted land.

Meanwhile, after decades of strong growth, world food production has reached a plateau and begun to fall behind population growth. By the year 2000, developing nations can expect a food deficit of more than 100 million tons a year unless the agricultural community can develop new methods to improve crop yields worldwide.

So earlier this month, a dozen traditional plant breeders and molecular biologists, who are worried about the devastating food shortages that may occur in the 21st century, gathered at a seminar* to consider what can be done to shore up international food security now.

International Potato Center

High-tech seedlings. *Vietnamese workers ready their cultured potato seedlings for planting.*

Biotechnology can help boost food supplies, they say, by producing nutritional crops that can better withstand drought or flooding, diseases, and pests—and grow in a fast and cost-efficient manner. Recombinant DNA techniques, in particular, are expected to speed up traditional plant breeding methods and help farmers reduce their dependence on pesticides and herbicides.

Yet, despite biotechnology's great promise for feeding the world's billions, the scientists admitted it will not be easy to transfer the technology to developing nations. The many constraints include suspicious farmers who worry that the developed nations will use their technology to undercut traditional exports from the Third World, such as sugar and cocoa butter. "If you're a farmer on the Ivory Coast and your main product is cocoa, and you hear that some guy in Hershey, Pennsylvania, is trying to produce cocoa butter in the lab, you're going to be scared to death," says W. Ronnie Coffman, chairman of the department of plant breeding at Cornell University.

And biotech companies currently have little financial incentive to invest in the particular problems of the Third World because of the poor patent protection offered in these nations. "The Third World is under no obligation to follow the patents issued in the First World, so it's easy to get stolen from," says Peter S. Carlson, founder of Crop Genetics International, a biotech firm in Maryland that's doing field tests of genetically engineered corn.

Despite those constraints, many of the scientists say it's just a matter of time before the seeds of biotechnology take root in the fields of developing nations. Their leaders are already taking the initiative of opening biotechnology centers to help them compete in the international marketplace. Several countries, including Nepal and Bhutan, have sought several millions of dollars from international organizations such as the World Bank, which is spending $700 million on agriculture in developing nations.

"Opening a biotech lab has the prestige of having a national airline,"— and about as much usefulness in some cases, says Peter R. Day, director of the Center for Agricultural Molecular Biology at Rutgers University. Where there is inadequate science training and personnel to transfer the biotech products to farmers, the money for "gee whiz" technology would be better spent on the bread and butter of agriculture—traditional plant breeding, agricultural education, and seed dissemination programs.

But the Third World leaders have good reasons for seeking their own biotech centers. They want to invest in their own labs and scientists, who would be more sensitive to the needs of local farmers. And they want to set their own research agendas, rather than relying on the First World to decide what genetically engineered crops would be most useful for them, says Stephen A. Vosti, a research fellow at the International Food Policy Research Institute.

And the Dalat farmers in Vietnam illustrate the effectiveness of such a home-grown effort. They originally heard about tissue culture technology from a Vietnamese agricultural extension official who had traveled to France, where he learned of the technique.

The Vietnamese were so enterprising they converted discarded U.S. Army gas canisters into makeshift autoclave pressure cookers to sterilize the gelatin media used for growing

*The meeting, which was sponsored by the Rockefeller Foundation, was held in Annapolis, Maryland, from 13 May to 16 May.

the potato tissue. They purchased the test tubes they needed from a local hospital, while banana leaves worked as biodegradable containers for the potato seedlings grown from the cultured tissue.

Recombinant DNA techniques may be more difficult to transfer than tissue culture methods because they require more training and more sophisticated facilities. But once a new biotech process is published, there is nothing barring scientists in developing nations from trying it out. While U.S. scientists spend an average of a decade to genetically engineer plants and test them in federally regulated field trials, foreigners may already be harvesting the fruit—or vegetables—of the biotech companies' labors.

Roger N. Beachy says that scientists in China and Thailand, among other nations, already are growing crops those countries' scientists produced with a technique developed by Beachy and his colleagues at Washington University and Monsanto Co. in St. Louis. In a widely regarded experiment, the St. Louis group inserted a gene encoding a tobacco mosaic virus coat protein into tomato plants. As a result, the transgenic plants make the viral protein and become highly resistant to tobacco mosaic virus infection.

Beachy doesn't know the current status of the foreign work in which the researchers are acting on their own to conduct field tests of these engineered crops—although some of these foreign countries have sent graduate students to work in his lab to learn the techniques. His own team's field trials have been under way in the United States since 1987, and he predicts it will be the mid-1990s before the Environmental Protection Agency gives them the go-ahead to sell the seeds.

Carlson of Crop Genetics International also predicts it will be late 1993 before his company sells its genetically engineered corn seeds. The seeds carry a gene from a soil bacterium, *Bacillus thuringiensis*. The gene is activated in the corn plant where it produces a protein that kills corn borers.

But the key to making any of these technologies work in the Third World is to find ways of making them compatible with classic farming approaches, the conference participants agreed. That means laying the groundwork for agricultural extension programs that reach out to small-scale farmers, such as the one that spread the use of tissue culture in Dalat. "Eventually, the products of the new technology will also have to work their way down that pipeline to get to these small-level farmers," says Dodds. "Biotech doesn't stand alone. These techniques will be of little use unless they are used along with existing methods."

■ **ANN GIBBONS**

Growing Crops in Saltwater

Ann Maddison/NRC

Salty harvest. *Sri Lankans extract leaf protein to make seawater candy and to improve traditional foods.*

Much has been made of biotechnology's potential to prevent international food shortages in the next century. But a far less glamorous technology—growing plants that thrive on briny seawater—may be another answer to the agricultural needs of developing nations. A 4-year study released last week by the National Research Council identifies hundreds of hardy plants that can survive in the brackish waters and arid lands of the world—characteristics that could make them the miracle plants of the 21st century. According to the new report, these so-called halophytes could "improve food or fuel supplies, increase employment, help stem desertification, and contribute to soil reclamation."

That's a tall order for such little-known flora as Distichlis, Salicornia, and Sporobolus. They are hardly household names, but the plants were once widely used. Ancient cultures, such as the Seri Indians in the southwestern United States, once pounded the seeds of a sea grass known as Zostera marina into flour. And the Cocopa Indians harvested Palmer's saltgrass from tidal flats in the California Gulf to make flour for their bread.

But now, saline agriculture appears to be headed for a revival, the scientists report after surveying 100 researchers in 30 nations. They found Israeli farmers irrigating specially bred tomatoes and cotton with saline water; Pakistanis growing kalar grass in waterlogged, high-saline soils as foodstuff for livestock; and Mexican farmers harvesting Salicornia, a succulent plant that thrives in seawater and produces a safflower-type oil. "The premise of the report is that the Third World has a lot of salinized land, so that makes these halophytes suitable for these lands," says Cyrus McKell of Weber State College in Utah and a member of the study panel.

Most conventional crops, such as beans and lettuce, shrivel under such tough conditions. Not only do halophytes survive, but they seem to thrive in the worst of soils, which could make them a valuable commodity in developing countries where millions of hectares of land are damaged from high salt content.

They also could be of use in the First World, particularly in the western United States where periodic droughts could someday threaten irrigation supplies for conventional crops and where some irrigated lands have become loaded with salt.

Farmers have many strains of halophytes to choose from, according to the study. They range from grasses that can be used for animal feed to fruit trees, such as the quandong, an Australian tree that produces a cherry-like fruit.

But these crops should not take the place of existing ones: To be truly useful in boosting world food supplies, they should only be introduced on lands where conventional crops cannot be grown, says the report.

Though a lot of useful plants are already suitable for widespread cultivation, biotechnology could make some halophytes even more valuable, the report notes. Genes for salt and drought tolerance could be taken from halophytes and introduced into conventional crops, such as asparagus and some strains of wheat, barley, and rice.

The report warns that much work remains before many wild plants are domesticated and turned into nouvelle cuisine. Take the Galapagos tomato. "Seed from a wild tomato found on the seashore of the Galapagos Islands produced tomatoes that were small and bitter," according to the report. But, happily, the problem has yielded to old-fashioned techniques: Cross-breeding with commercial tomatoes produces a fruit that can be irrigated with saltwater but still tastes good. "My feeling was they were even more tasty than regular tomatoes," reports McKell, who says that part of the job of participating in the study was to taste the fruits of the seawater. ■ **A.G.**