Advanced technologies readied for potato and sweetpotato producers

In an effort to serve the poorest and most vulnerable members of society, CIP scientists—working side by side with researchers in Africa and Latin America—are pairing genetic diversity with the tools of modern molecular biology to provide solutions to a series of long-standing problems

Public sector donors and private foundations have provided support for new initiatives that should set the stage for a dramatic reduction in the use of agro-chemicals and provide increased market access for smallholder potato and sweetpotato farmers.

After nearly a decade of research, for example, CIP and African scientists recently concluded that the development of a transgenic sweetpotato may be the only way to control one of Africa's major crop pests: the sweetpotato weevil. Despite concerted efforts over a ten-year period, scientists have been unable to identify sources of genetic resistance or develop integrated pest management practices that provide even minimal control.

Weevils pose a significant burden to Africa's sweetpotato farmers. Production losses can easily reach 60 percent because even slightly damaged roots are unfit for the market or for human consumption. The impact of such losses is particularly devastating in Eastern and Central Africa where sweetpotato is grown mainly for household subsistence.

"Our intention is to incorporate into sweetpotato a gene derived from a bacteria that acts as a natural pesticide," says Marc Ghislain, head of CIP's Applied

Biotechnology Laboratory in Lima. Known as Bt, or *Bacillus thuringensis,* the bacteria is widely used as a bio-insecticide by organic farmers. Crops containing Bt genes are the second most widely grown transgenic plants, and most importantly, they are considered safe for human consumption.

"At least that's the consensus within the scientific community," Ghislain says, "although critics of transgenic crops may still choose to challenge that view." A recent report from Africa's leading potato and sweetpotato research network, PRAPACE, acknowledges the advantages of the Bt sweetpotato. PRAPACE is the French acronym for the Regional Potato and Sweetpotato Improvement Network in Eastern and Central Africa.

"Frankly, we have little choice but to use Bt," Ghislain says. "There appears to be no other way to control weevils. If there were a better way to achieve the same result, we would certainly pursue it."

Because the types of weevils that attack African sweetpotatoes are not present in South America, where CIP's biotech team is located, the research will be conducted in the United States and in Uganda. The initiative, budgeted at US$850,000 over three years, is expected to start up in 2004.

CONSUMER-FRIENDLY GENES

Ghislain notes that the project will be the first to make use of a new technology that should reduce consumer concerns about the safety of bio-engineered food crops. Developed at CIP with support from the Rockefeller Foundation, the technology involves the use of a tobacco gene as a "selectable marker," which provides the vehicle for transformation, instead of the antibiotic resistance markers usually used in genetic engineering. Although extensive studies have demonstrated that antibiotic resistance genes are not a threat to human health, consumer concerns persist. The new selectable marker provides a means of reducing these fears.

To address other important biosafety concerns, researchers plan to insert the Bt genes into easily distinguished, non-flowering varieties of sweetpotato. The use of such easy-to-identify plants should help farmers to recognize the transformed varieties, while the fact that the plants do not flower will prevent the movement of the Bt gene to other sweetpotato varieties and weeds. In addition, scientists from Uganda's National Agricultural Research Organization will screen all the transformed plants in special facilities to ensure full confinement. The best-performing lines will be field-tested as soon as national biosafety regulations are in place.

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A virtual potato herbarium is one of the innovations introduced by CIP researchers to help document and understand biodiversity.

Tracking the past, charting the future

CIP scientists worked throughout much of 2003 to complete the first major components of the Center's electronic germplasm acquisition, tracking, and distribution system. The system, which charts germplasm movements back to the 1970s, was designed in part to help the Center fulfill its obligations under the International Convention on Biological Diversity. It was assembled from some 20 independent databases and from old paper archives, and includes information on the origin and distribution of thousands of genetic samples and herbarium specimens.

"It's taken us almost five years to build a computerized platform that integrates information going back nearly three decades," says CIP Plant Breeder Enrique Chujoy. "It is now possible to determine, with a high degree of certainty, what materials a cooperator has received, where there are gaps, and what we can do about it."

The system was recently used, for example, to evaluate all of the germplasm sent to Ethiopia over a 25-year period. The results indicated that the 1,453 potato breeding materials sent to Ethiopian cooperators are a cross section of older CIP breeding lines whose resistance to late blight disease has since proven to lack durability. Accordingly, Center scientists are now shipping to Ethiopian partner agencies hybrids that provide longer-lasting resistance and earlier harvests (see *Harnessing the Trend: A Millennium Strategy for Africa*, page 57). Ethiopia was identified by the Center's visioning exercise as a key target for future cooperation.

One of the system's most important features will be an electronic catalog of CIP advanced breeding lines. The catalog, which will be brought on-line in 2004, provides photographs of all available materials, as well as data on how they are likely to perform under specific conditions. Until now, cooperators who requested CIP breeding materials were asked to first provide information on local conditions. This information was then evaluated by CIP scientists, who would then provide the materials they considered best adapted to the environment in question.

"Now," says Chujoy, "anyone with a computer and Internet access will be able to request the genetic material they think is best suited to their local conditions." In addition, cooperators will be able to see where a specific accession originated and where it has been sent. The system should be accessible to the public by the end of 2004.

Biosafety regulations for Africa's transgenic sweetpotatoes

By 2009, African scientists and CIP researchers plan to deploy genetically engineered sweetpotatoes to address two priority productions problems: weevil infestation and virus diseases.

Although the new plant types will offer substantial benefits in the form of food security and family income, lack of knowledge about how foreign genes (also known as transgenes) will combine with traditional farmer varieties could present important obstacles.

"It is highly probable that genes from genetically engineered sweetpotatoes will eventually spread to Africa's traditional varieties unless steps are taken to establish regulatory and monitoring procedures," says Dapeng Zhang, a former CIP sweetpotato breeder now with the United States Department of Agriculture.

The spread of transgenes could be higher in Africa than in other parts of the world because the continent's sweetpotato fields tend to be small and are planted in close proximity, and because of the absence of formal seed systems, which register varieties and monitor their use. The fact that farmers mix sweetpotatoes with secondary crops, grow many different varieties, and save their planting material for the following year's crop further complicates the problem.

Marc Ghislain, head of CIP's Applied Biotechnology Laboratory in Lima, and colleagues are developing plans to characterize Africa's sweetpotato cropping systems and assess sweetpotato pollination mechanisms. By developing knowledge on the reproductive biology of African sweetpotato varieties, they plan to help national regulatory agencies to develop policies and procedures that will allow them to safely introduce transgenic varieties.

Zhang and Ghislain both emphasize that while biosafety procedures for crops grown from conventional seeds—such as corn or wheat—are well established, most of these are not relevant for crops such as sweetpotato, which are vegetatively propagated in subsistence farming systems.

"Regulations are needed to ensure that genetically engineered (GE) and non-GE varieties can exist side by side," Ghislain says. "The only way to do that is to have the technology and the policies in place that will allow for effective segregation."

Ghislain also recommends the adaptation of methods for risk assessment and the establishment of monitoring systems to evaluate the long-term impact of transgenic sweetpotatoes on the environment and on farmers' conservation of agro-biodiversity.

"CIP's role in the project will be largely advisory," Ghislain adds. "Our contribution will be to provide scientific expertise, increase local capacity through training, and serve as a facilitator between patent-holders, regulatory agencies, researchers, and civil-society." It is expected that the International Service for the Acquisition of Agri-biotech Application's (ISAAA) Africenter for technology transfer will also participate in the project, as will the CABI Uganda Biotechnology Initiative, the UNEP Biosafety Project, ASARECA (the Association for Strengthening Agricultural Research in Eastern and Central Africa), and the Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), an ASARECA network that promotes regional economic growth through the application of growth-enhancing agricultural policies.

New opportunities for Andean potato farmers

In South America, meanwhile, broad-based international partnership will play a role in a project that will provide farmers with high-value, low-input disease-resistant potato varieties. With help from the German Ministry for Technical Cooperation (GTZ) Germany, and building on past investments made by the European Union, CIP scientists are now working with partners in five countries to use a pool of newly developed potato hybrids that carry broad-spectrum disease resistance derived from genes found in wild Andean potatoes.

The new varieties—which incorporate resistance to late blight disease and Potato Virus Y, both of which are priority problems in the high Andes—are expected to begin reaching farmers within three years.

"The estimated impact of the new varieties is considerable," says Plant Breeder Merideth

The tools of molecular biology can help to produce new crops, offering urgently needed solutions to a problem that plagues African farmers: the sweetpotato weevil.

Bonierbale. "They should benefit at least 200,000 Andean farm families before 2009." Bonierbale is the Head of CIP's new Germplasm Enhancement and Crop Improvement Division.

An important feature of the project, Bonierbale notes, is that it will include extensive DNA characterization and identification of disease-resistant accessions in national and international genebanks. The data derived from this research will be incorporated into databases, helping partners to speed up their use of resistant wild species in breeding programs.

The project will also use genetic maps to identify complementary sections of potato chromosomes that can be "pieced together," thereby building genetic combinations that will provide long-lasting resistance in farmer- and consumer-preferred crops. "Our intention is to adapt modern molecular tools to the needs of national breeding programs as quickly as possible," says Christiane Gebhardt of the Max Planck Institute for Plant Breeding Research (MPIZ) in Cologne, Germany. MPIZ is a long-time CIP collaborator.

Bonierbale and Gebhardt anticipate that project activities, which range from molecular genetics to participatory variety selection, will reduce the time required to test and release improved potatoes by at least five years.

"The project will rely on social scientists to organize focus groups that will identify farmer and consumer preferences for potato varieties," Bonierbale notes. Economists will also evaluate potential benefits of the new varieties in terms of household economics, human health, and the environment. Some of the benefits expected, in addition to higher profits, are reduced fungicide use, improved market acceptance, and stabilized prices.

The first group of potatoes to emerge from the project is expected to cover approximately 60,000 hectares, an area equivalent to about 10 percent of the combined potato growing areas of Bolivia, Colombia, Ecuador, and Peru. Roughly 50,000 to 75,000 farm families should benefit in this initial stage.

Project partners, in addition to MPIZ and CIP, include Bolivia's *Fundación PROINPA,* Colombia's *Universidad Nacional*, Ecuador's *Instituto Nacional de Investigaciones Agropecuarias*, Peru's *Instituto de Biotecnología de la Universidad Nacional Agraria La Molina*, and Germany's University of Tübingen.