Diversity
to Foster Scientific Innovation

STRIGA:
Search for a Long-Term Solution

Agronomists classify it as the parasitic weed *Striga hermonthica*. Economists report that it inflicts yield losses ranging from 20 to 80%, and that across sub-Saharan Africa it robs US$ 1 billion in lost productivity from more than 100 million people, most living on subsistence or smallholder homesteads. Maize farmers in Western Kenya simply and distainfully curse it as "witchweed." One thing they all agree on is that this scourge, which exhibits a remarkable resistance to conventional controls, is on the rise—both in terms of area affected and intensity of infestation.

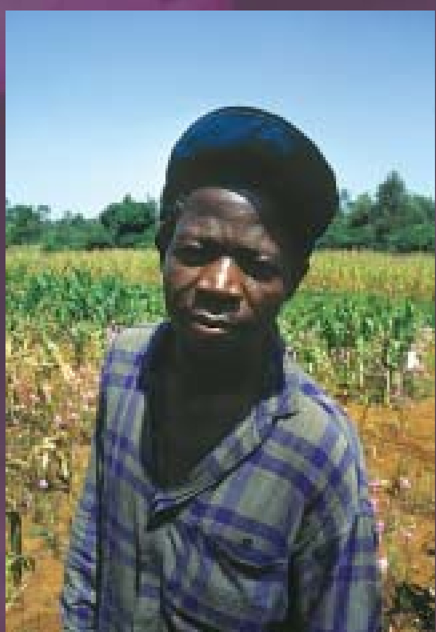
CIMMYT's Applied Biotechnology Center (ABC), together with the Department of Animal and Plant Sciences at the University of Sheffield, is looking for solutions. Funded by the Rockefeller Foundation, scientists from the two institutions are looking for unconventional sources of resistance to *Striga*. Leading CIMMYT's efforts is molecular geneticist/physiologist Sarah Hearne.

Since 1999, Hearne says, CIMMYT has screened accessions of *Tripsacum* and teosinte (wild relatives of maize) for resistance to *Striga*. The screens revealed that apomictic tetraploid *Tripsacum* is very resistant. Results with teosinte were not as encouraging, although three accessions showed some potential. Jane Ininda, of the Kenya Agricultural Research Institute (KARI), will screen many more teosinte accessions, representing a full range of diversity, later in 2002.

Maize-*Tripsacum* hybrids, generated by the CIMMYT-Institut de Recherche pour le Développement (IRD) apomixis project, have also stirred a lot of interest (see p. 42). These plants have various combinations of maize and *Tripsacum* chromosomes. Hearne began screening these hybrids in early 2002, and 60 are being grown and infected with *Striga* in root observation chambers at Sheffield to evaluate resistance and observe the form it takes. Once resistant lines are identified, Hearne says, it should be possible to determine the chromosomes responsible for *Striga* resistance by comparing the levels of resistance in the lines and the chromosomes they are known to carry. "If the trait is located on a lot of chromosomes," she says, "it's going to be very difficult to introduce the trait using conventional breeding—it probably won't happen. But if it is located on a single chromosome, we could potentially move the gene or genes controlling the resistance into maize."

Hearne is also trying to identify the basis of *Striga* resistance in *Tripsacum* by comparing differences in gene and protein expression between resistant *Tripsacum* and susceptible maize. The protein research is conducted in collaboration with Christophe Brugidou of IRD. If researchers identify candidate gene(s) responsible for resistance, it may be possible to introduce resistance into maize using a transgenic approach.

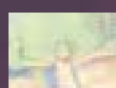
An underground epidemic: Farmers can lose 80% of their maize crop to *Striga.*



Finally, Hearne is looking at the use of genes tagged by Mutator, a so-called transposable element that jumps into genes that control plant functions and turns them off. "For instance, if you had a gene for red pigmentation in the grain and the Mutator jumped into that gene, you would cease to have that pigmentation. We're applying that same principle in the search for *Striga* resistance, in that there may be a regulatory gene that prevents maize from activating defenses against the weed."

During 1998–99, about 8,000 Mutator-tagged maize lines were screened under controlled experimental conditions. About 80 showed some level of resistance. Since then, that group has been narrowed to about 20 entries, says Hearne. One looks particularly promising. Once the gene is characterized, researchers will attempt to cross it into adapted material and check its performance.

Although it will be a few years before results of this work reaches farmers' fields, Hearne is optimistic that new knowledge about plant responses to *Striga*, and some of the research products, will provide long-lasting resistance to the parasitic weed and grant relief to many generations of African farmers.



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A Bridge to BIOFORTIFIED Wheat

Filling empty stomachs, the priority when people are starving, is not enough in the long term: people need food with the nutrients they require to lead healthy and productive lives.

An estimated 3 billion people in the world who do not go hungry nonetheless suffer the debilitating effects of unhealthy diets. People who eat mostly cereal-based foods can lack such essential nutrients as iron, zinc, and vitamin A. Some developing countries overcome this deficiency by distributing supplements to the population and/ or fortifying food with nutrients. Some of these programs have been successful, but they are expensive.

Biofortified™ Crops

An excellent means of complementing these programs would be to breed crop varieties with increased levels of minerals and vitamins. Biofortified crops could benefit malnourished populations cheaply and sustainably.

Creating biofortified versions of the main food crops is the idea behind the CGIAR Biofortification Project* funded by Danish International Development Assistance (Danida) and coordinated by the International Food Policy Research Institute (IFPRI) and the International Center for Tropical Agriculture (CIAT), which is also working on raising the micronutrient content in beans and cassava. CIMMYT is working on generating nutrient-enriched maize and wheat. Other CGIAR centers, such as the International Rice Research Institute (IRRI) and the International Potato Center (CIP), are working on their respective crops.

The project relies on the collaboration of the University of Adelaide in Australia and Cornell University in the USA, whose laboratories are testing for micronutrient and vitamin A content and micronutrient bioavailability (i.e., whether nutrients can be assimilated by humans and animals).

A Bridge to High-Nutrient Genes

Since most improved bread and durum wheat varieties lack high concentrations of iron and zinc in the grain, the search is on for good sources of the genes that control these traits. CIMMYT scientists headed by Ivan Ortiz-Monasterio have been screening materials stored in the CIMMYT genebank for five years now. They have found that wheat's wild relatives carry the highest levels of iron and zinc in the grain. Although grain nutrient levels vary depending on where plants are grown, trials in northwestern Mexico revealed that, compared to an average wheat, some of the best wild relatives had 1.8 times more zinc and 1.5 times more iron in the grain.

How to tap into genes contained in these wild species? The Wheat Wide Crosses Unit has already provided the means: bridge wheats. These wheats act as a "bridge" for transferring favorable genes from wild species to improved bread wheat. In this case, they are generated by crossing a durum wheat with a related wild grass. That is a reproduction of the chance crossing that occurred in nature between those two species and first gave rise to bread wheat about 8,000 years ago.

Bridge wheats (also called synthetic wheats) are true bread wheats and can be crossed readily with high-yielding varieties. Crossing bridge wheats with improved wheat is important because it helps to eliminate negative characteristics. The resulting wheats will be like their improved parents, except for the desired trait from the wild parent (in this case, high iron or zinc content in the grain).

Bread wheat breeders Maarten van Ginkel and Richard Trethowan use bridge wheats as a source of the high iron and zinc traits in their crosses with high-yielding lines. Since the inheritance of high levels of the two micronutrients seems to be linked, breeders can use the same bridge wheats for both traits. The researchers have advanced to the third and fourth generations, which means they are making good progress.

Work on improving the vitamin A content of wheat is just beginning. The materials in the CIMMYT wheat genebank are currently being classified for orange pigmentation, which may indicate high levels of beta-carotene, the precusor of vitamin A.

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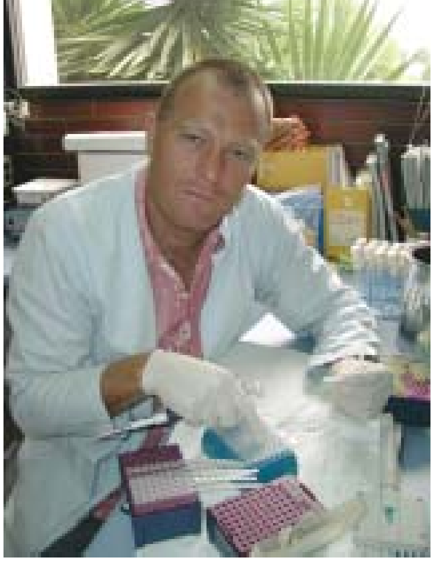
* Initially reported as the CGIAR Micronutrients Project in our Annual Report, *CIMMYT in 1999-2000*, pp. 8-10.



"The whole situation with apomixis research reminds me of the 1902 Georges Méliès movie, A Trip to the Moon. *In the movie, they simply shot a large bullet from a giant gun at the moon, and after a short time it struck the giant cheese orb. Sixty-seven years later, we actually landed on the moon, but not until we had developed and fully understood a huge range of new technologies, as well as the basic scientific concepts involved. Now, in our apomixis work, we have reached the stage where we understand that our initial approach was too simple, and we need to know more."*

—Enrico Perotti, apomixis research team member

APOMIXIS: Why Is It Taking So Long?

Over 13 years ago, the Institut de Recherche pour le Développement (IRD) joined with CIMMYT to initiate work on creating "apomictic" maize. Hopes were high that by crossing maize with its wild apomictic relative *Tripsacum*, researchers could breed a maize plant that would produce clones of itself over generations (see "What Makes Apomixis a Valuable Trait?", next page).

One need not be familiar with the terminology or the process to recognize the revolutionary potential of apomixis. Hybrid production could be greatly accelerated, breeding for niche environments (small environments with unique conditions) could be economically feasible, and poor farmers could recycle seeds that maintain hybrid characteristics.

Knowledge about apomixis has grown considerably, and so has impatience to develop apomictic maize. So exactly why *has* it taken so long?

The First Approach

"At the beginning," says research team leader Olivier Leblanc, "we were working on the premise that apomixis is a simple trait and that it should not be overly difficult to transfer a single-gene trait to maize with the existing technology. We pursued an applied breeding rather than a basic science approach. We weren't interested in the mechanisms and the molecular basis for the phenomenon. We just needed to find that one and only apomictic specimen that was hiding out there among half a million experimental plants. We never found it."

Therein lies much of the impatience. In plant breeding, if you identify a source of variability for a given trait, eventually, through step-by-step plant crosses, the desired trait can usually be incorporated into maize varieties or lines. As it turns out, apomixis is complex. It certainly did not yield to a step-by-step procedure.

Does this mean that those years of work were unfruitful? No. In science, as false leads are discarded, efforts are redirected based on the insights obtained, according to David Hoisington, director of CIMMYT's Applied Biotechnology Center, where the research on apomixis takes place.

"Because we have such a strong team, partnerships, and advances in science," Hoisington explains, "we can continue our progress toward the ultimate goal, even if we change roads every once in a while."

The Road Less Traveled

Although the creation of apomictic maize remains the team's clear goal, the route there has changed from a relatively mechanical approach—transferring the apomixis gene(s) directly from *Tripsacum* to maize—to exploring other options that require better understanding of the apomictic process in general.

Most teams working on apomixis, according to Leblanc, are investigating and manipulating the sexual pathways of plants to produce an apomictic outcome. The CIMMYT-IRD team remains committed to using an apomictic plant and a related crop plant. In doing so, they can draw on their long experience with *Tripsacum*, "a truly beautiful model plant for apomixis," says team member Daniel Grimanelli, "which is an original approach compared to those being pursued by other groups." They are investigating the cell biology and molecular genetics of the processes behind apomixis, as well as barriers within the maize genome to the transfer of the characteristic.

They also draw support from a consortium formed in 1999 to accelerate progress. The IRD and CIMMYT joined in a five-year agreement with Pioneer Hi-Bred, Groupe Limagrain, and Novartis Seeds (now Syngenta) to bring their diverse strengths to bear on the apomixis challenge. For the CIMMYT-IRD team this means access to useful biological material, databases, information, and experts, as well as additional financial resources.

The team is excited about its new direction. "We're working on novel approaches and have some nice stuff cooking," says Leblanc. "But it's too soon to talk about major achievements. We're out of the prediction game for good."

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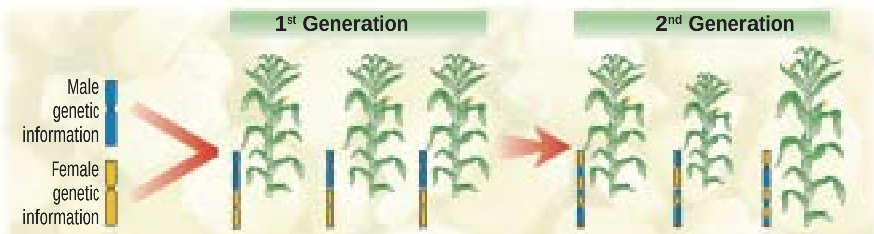
What Makes APOMIXIS a Valuable Trait?

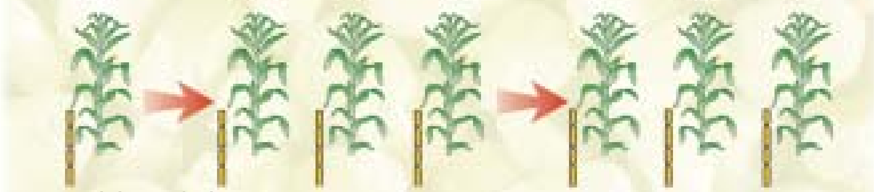
Apomixis—asexual reproduction through seeds—results in plants that are exact clones of the mother plant. The trait occurs naturally and has been identified in more than 400 species of plants, including some varieties of *Tripsacum*, a wild relative of maize. With an apomictic mode of reproduction, exact copies of the chromosomes are transferred from the mother plant to the progeny, making each offspring a clone of its ancestor. This direct transfer of chromosomes (and therefore traits) continues generation after generation.

The implications of transferring the apomixis trait to a major cereal crop such as maize are tremendous. Breeders would be able to greatly reduce the time and expense required to produce new varieties, for example, by instantly "fixing" a desired genetic composition, which normally takes several seasons. Apomixis is of particular interest to CIMMYT because it would make *niche breeding*, the development of cultivars tailored to unique agroecological areas and very specific uses, more economically feasible.

Seed producers would be able to reduce the cost of producing hybrids, which could translate into lower seed prices for farmers. Farmers in developing countries who obtained improved seed carrying the apomixis trait would be able to recycle their seed indefinitely, while maintaining various yield-enhancing properties usually associated with hybrids, which cannot be productively recycled.

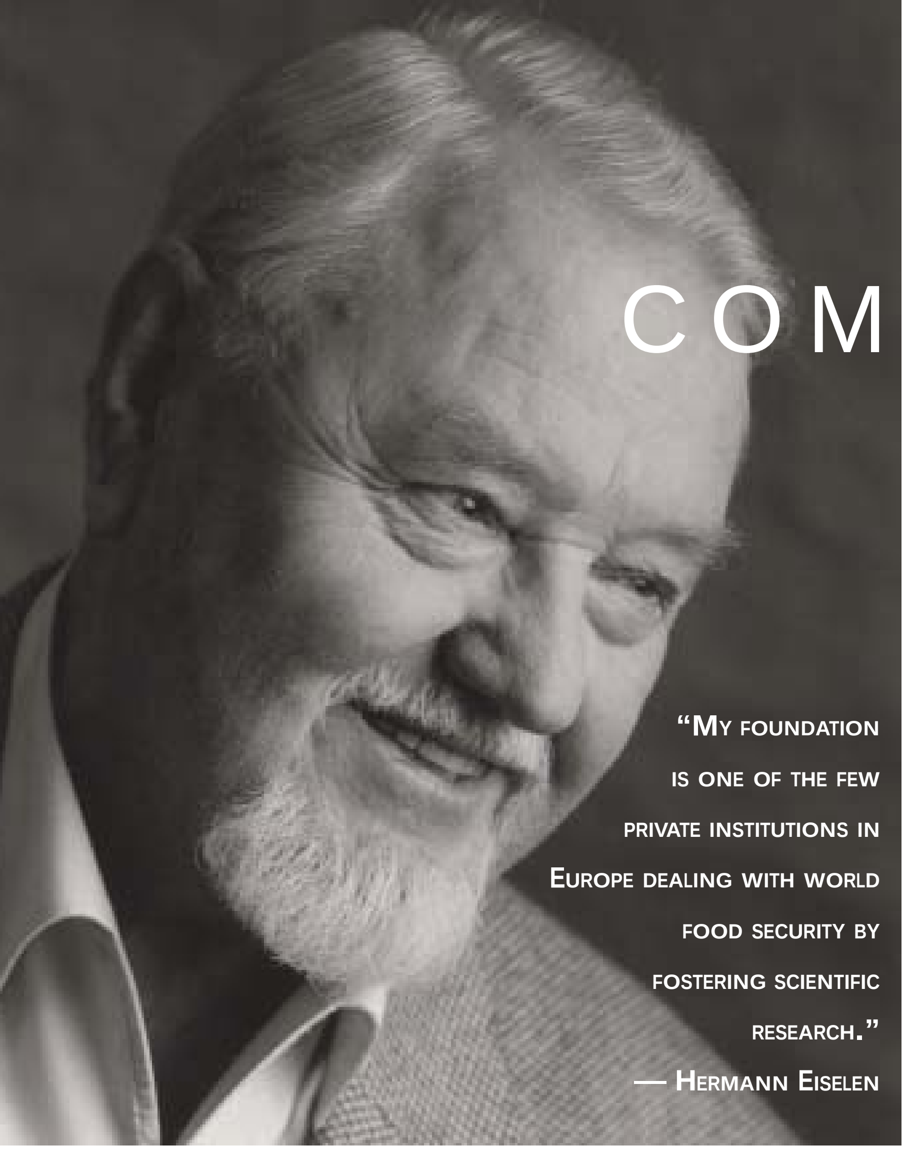


Sexual reproduction: Hybrid maize produced sexually (first generation) displays identical genetic makeup. Maize plants depicted in the second generation represent the use of seed recycled from hybrids, a common practice in many developing countries. These second-generation plants are genetically and physically diverse.



Apomictic reproduction: Hybrid maize produced apomictically (asexually) also displays identical genetic makeup in the first generation, but it retains its genetic composition and characteristics through the second generation and beyond.

Private COMMITMENT Leads to Public Good



"MY FOUNDATION IS ONE OF THE FEW PRIVATE INSTITUTIONS IN EUROPE DEALING WITH WORLD FOOD SECURITY BY FOSTERING SCIENTIFIC RESEARCH."
— HERMANN EISELEN

Molecular geneticist Marilyn Warburton arrived at CIMMYT in 1998 with a goal: to develop large-scale methods for fingerprinting wheat and maize (see "What Is Genetic Fingerprinting?", p. 47). Forty years before that, Hermann Eiselen arrived at what was to be his lifelong mission—a commitment to fighting hunger through research. Their paths crossed through a CIMMYT project on the genetic characterization of wheat.

Large-Scale Genetic Fingerprinting Becomes a Reality

Warburton and David Hoisington, director of CIMMYT's Applied Biotechnology Center (ABC), had several reasons for wanting to conduct large-scale fingerprinting of wheat and maize at CIMMYT. This capability would give researchers new insight into the parentage of thousands of lines, varieties, and landraces used in their work. They would have a new clue as to whether the desirable genes they sought were present. They could incorporate those genes more quickly into new varieties and could ensure that new varieties were genetically diverse. Fingerprinting would also help genebank curators collect and maintain genetic resources more efficiently.

The ABC could screen a few dozen varieties a month. The goal was to screen hundreds. “Given the size of our seed collections,” says Warburton, “people were not interested in fingerprinting only a few varieties. We needed to develop high throughput capabilities to respond to CIMMYT’s needs.”

Funding was quickly procured to develop protocols for maize, mainly from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the French Institut National de la Recherche Agronomique (INRA), and PROMAIS (a consortium of private French companies). Support for similar work in wheat was less forthcoming.

Enter Hermann Eiselen, whose family has supported research at the University of Hohenheim, Germany, over the last four decades. Most of this philanthropy has been directed to students interested in applying science to international development, particularly in agricultural sciences and nutrition. Twenty years ago, the family handed these tasks over to the Eiselen Foundation, where Hermann is Chairman of the Board.

Finding the Funding

Through University of Hohenheim professor Albrecht Melchinger, Eiselen learned about CIMMYT’s situation and pursued support through GTZ and his own foundation. Eiselen’s interest in the wheat project may have been piqued by the fact that his family’s fortune came from products for the bread making industry (his affection for bread and baking is evidenced by his family’s founding of the Bread Museum in Stuttgart, Germany).

“Biotechnology is one of the key sciences for increasing agricultural production to help alleviate world hunger,” says Eiselen. “On my initiative, the German government entered into the first and, to my knowledge, only public-private partnership by the nation in development-oriented agricultural science, this joint project between CIMMYT and the Institute for Plant Breeding in Hohenheim. I am proud that my foundation is one of the few private institutions in Europe dealing with world food security by fostering scientific research, and it is my great desire that other nonprofit organizations do the same.”

Capable Hands to Launch a New Project

The three-year project was launched in 2000. Susanne Dreissigacker and Pingzhi Zhang, PhD students at Hohenheim, arrived at CIMMYT to start developing a high throughput fingerprinting method for wheat. It was a daunting task.

“First, we had to identify markers that would allow us to cover the whole genome,” Warburton says. “We wanted at least two markers per chromosome arm for each of wheat’s 21 chromosomes.” Further complicating the job was the fact that the wheat “genome” actually falls into three similar but not identical genomes, meaning that the markers had to be specific to each genome.

“The students and I ran through more than 200 SSR markers. We wound up with nearly 84, the requisite number, though we still had only one marker for a few chromosome arms.” The task was complicated by the dearth of good markers in the public domain. Negotiations with Dupont freed some more effective markers that will be publicly available at the end of the year.

The next step was to identify markers that could be run in the same gel. (If the various markers registered in the same place on the gel, it would be difficult to distinguish one from another.) Finally, software had to be adapted to “score” the markers, which would tell the scientists what gene sequences were present in the tested variety or line.

With the markers selected and the protocols in place, Warburton and the students analyzed hundreds of wheat lines. They looked at important CIMMYT wheats to determine whether genetic diversity was increasing or declining over time. Compared to the 1970s, present-day wheats carry more genetic diversity, indicating that breeders are using new sources of variation and that there is no imminent threat of diminished diversity. Much useful information was obtained, but the biggest impact so far has been on landrace collection and genebank storage strategies (see “Fingerprinting Yields Surprising Findings,” p. 46).

Last June, the students returned to Hohenheim to complete their analyses and write their theses. “It’s a little sad to lose them and their very capable hands,” reflects Warburton, “because now that we’ve got all the data, the exciting stuff starts. Our relationship evolved from a mentoring situation to a team relationship during those two years. By the end of the second year, they were teaching me a lot and probably knew the sequencer better than anybody in the lab.”

Hermann Eiselen could not have hoped for more.

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Fingerprinting Yields SURPRISING FINDINGS on Wheat Diversity

Capturing diversity by collecting and storing wheat landraces is a tricky business. Should collectors go to many fields and obtain a single sample from each? Or should they go to a single field and collect a multitude of samples? Should sampling strategies be the same for regions that are a center of origin as for those that are not? And that's just the beginning. Storage and maintenance strategies also differ based on the variation in each landrace. Genetic fingerprinting can answer these questions.

CIMMYT molecular geneticist Marilyn Warburton and her team looked at about 150 landraces collected from various countries using a range of methods. "Passport data," when available, supplied information about where a sample was collected, how it was collected, and how it was stored. For example, a sample could be collected as a single spike (ear) of grain from one plant, as spikes from several plants from the same field that were conserved separately by the genebank, or as part of a "bulk" of seeds—seeds collected from a number of plants thought to be representative of a given landrace and maintained in the same sample. The analysis reinforced long-held views on collection but, surprisingly, contradicted others.

The team found tremendous genetic differences among landraces grown within a country considered a center of origin for wheat, even if the landraces went by the same name and were collected from adjacent villages. On the other hand, in countries not designated as centers of origin, even landraces going by different names appeared to be very similar genetically.

"These findings tell scientists to focus their collecting in centers of diversity," says Warburton. "While we knew that in theory, we now have the data to back it up."

However, the team came up with disconcerting results that showed that the amount of variation within a landrace sample did not necessarily correlate with how it was collected—a finding at odds with the conventional wisdom.

"If the sample was collected as a bulk," Warburton explains, "you'd expect to see several different alleles—forms of the same gene—at each marker, but all too frequently we saw only one or two alleles. Either the field where we collected the sample was planted to a single genotype, or some variation was lost after years in storage."

Such samples should not be treated as bulks but rather as a single inbred line. When the sample is regenerated, fewer seeds can be planted. In addition, breeders can be informed that there is limited variation in the line and it can be treated as an inbred.

A few samples collected from a single spike showed a lot of variation. There are several possible explanations for this unexpected result. The sample may have been an outcrossed hybrid (a rare but not impossible occurrence), seeds may have been mixed during some stage of handling, or the passport data were simply incorrect. Regardless of how the variation occurred, wheat breeders or genebank curators should not treat these samples as inbreds. They should treat them as bulks and conserve their diversity.

"This work provided an immediate practical payoff for the genebank," says Bent Skovmand, head of the wheat genebank. "By employing these techniques on a wider scale, we can help people collect and store genetic resources more efficiently, avoid loss of variation, and save money by growing only the number of plants needed to retain the genetic diversity in a particular sample."

What Is Genetic FINGERPRINTING?

Genetic fingerprinting is probably more widely known for its uses in people—where it is used to determine paternity or indicate whether a person was present at a crime scene—than for its uses with plants. However, just like fingerprinting in humans, fingerprinting in plants can clear up a few mysteries.

Known also as "DNA fingerprinting" and "DNA profiling," fingerprinting in plants is based on the assumption that every individual variety or population has a genetic profile, revealed through its DNA, that is unique to that variety.

Researchers obtain samples of DNA from plant tissue and use several techniques to produce a "fingerprint" that looks like a series of bands of varying size, much like a bar code. The bands for one variety can be compared to bands for other varieties to detect similarities and differences. The more similarities there are, the more related the two varieties are, and the parents of the variety (or sibling varieties sharing the same parents) can be determined.

Although breeders generally have a very good idea of the origins and probable genetic advantages of the varieties or lines they develop, fingerprinting adds greater certainty to their work and helps them to work more rapidly. Closely related lines frequently share the same characteristics; thus, if one line has a favorable performance under certain conditions, lines closely related to it probably will, too. Also, in hybrid breeding, lines that are unrelated generally create better performing hybrids than lines that are related to each other or are very similar genetically. DNA fingerprinting can help breeders decide which varieties to cross with which.

Another problem that can confound plant breeding is that varieties found in several parts of the world (or even the same country or province) can have the same name but may not even be related. Fingerprinting can determine if varieties with the same name are truly genetically identical. This information helps breeders and also helps genebank curators decide which seed to conserve.

IMPACT
Studies: Room for Improvement?

Reaching the right people: International research organizations have documented how their work helps the poor, but are the results of these impact studies making a difference?

The complex and costly nature of good impact assessment studies and the multiplicity of factors that determine their outcome were among the issues discussed during an international conference held in Costa Rica in 2002.

The conference, provocatively entitled, "Impacts of Agricultural Research and Development: Why Has Impact Assessment Research Not Made More of a Difference?", was hosted by the CGIAR's Standing Panel on Impact Assessment (SPIA) and the CIMMYT Economics Program. Leading experts reviewed impact assessment studies, communicated the pivotal role of research and development to policymakers, and shared best practices.

Do We Learn from Our Mistakes?

"Experience suggests that one of the best ways to achieve food security, good environmental stewardship, and sustainable economic development is through the development and application of improved agricultural technologies," says Prabhu Pingali, director of the CIMMYT Economics Program at the time of conference. He notes that these improved technologies take a long time to develop, and their future availability depends largely on current investments in research.

"If current investments are to be effective, we have to understand the outcomes of past investments," says Pingali. "This is why our conference focused on ways to make impact assessment more understandable."

Participants developed principles and strategic guidelines for future impact studies. They examined the multiple purposes of impact assessment—accountability to donors, improving future research, resource mobilization, and public awareness. Mention was also made of the need for multidisciplinary studies that look at a range of impacts.

"People want information that guides them on design, program or project choices, on how to allocate resources across programs or projects, or to demonstrate at the completion of a project that resources were effectively used," says Alex McCalla, emeritus professor in the Department of Agricultural and Resource Economics at the University of California-Davis and Chair of CIMMYT's Board of Trustees.

McCalla points out that impact assessment has become more complicated because there are more players with more objectives, and they demand more sophisticated analysis. "Answering questions of impacts for these multiple players with multiple objectives, using complex conceptual models, has made impact assessment more costly," he says.

Communicating Impacts to Funding Agencies and the Media

Representatives from funding agencies such as GTZ, the International Fund for Agricultural Development (IFAD), and the US Agency for International Development (USAID) outlined issues that concerned donors. They emphasized the need for more credible results, including a more balanced selection of case studies that examine research failures as well as successes.

A media panel included journalists from *The Economist* and *The Hindu* and Barbara Rose, executive director of Future Harvest at the time of conference. The panelists observed that journalists are interested in stories that are relevant to current problems such as environmental degradation, poverty, and global warming. Because myriad issues vie for journalists' attention, it is critical to target the right audience and media outlet for messages about research impacts.

Immediate Impacts of the Conference

The conference exceeded expectations. "There appeared to be a real openness to rethinking how impact assessment is done at the Future Harvest Centers," remarks Rose. Archana Godbole from the Applied Environmental Research Foundation in India and Carmen Nieves Mortensen from the Institute of Seed Pathology in Denmark say that they learned a lot. "I have to admit I was surprised to see that even after four long days of meetings, the room was still packed," says SPIA chair Hans Gregersen.

Instead of issuing a traditional proceedings volume, conference organizers are assembling selected papers for publication in special issues of professional journals. "Special issues reach a much larger audience than proceedings," says Michael Morris, assistant director of the CIMMYT Economics Program. "They're externally reviewed and regarded as more substantial publications."

Special issues are currently being prepared for *Agricultural Economics, Quarterly Journal of International Agriculture*, and *Agricultural Systems*. Work has also begun on the development of a web site to promote best practices in impact assessment, disseminate results, foster dialogue between impact assessment practitioners, and demonstrate organizational learning.

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Achieving Uncommon Things: Biotechnology Network in Asia

The first slide appeared on the screen and B.M. Prasanna read it through to the last sentence. " '*The purpose of an organization is to enable common men'*—and of course we also mean women—'*to do uncommon things.'* These words are from Peter Drucker, the pioneer of management theory," Prasanna explained, "and they speak directly to why we are here today."

Individual genius is good, but organized collaboration may be better. AMBIONET team members from Malasyia in the lab with Luz George, project coordinator (back row, left) and Tony Perez of the Asian Development Bank.

The occasion was the initiation of Phase II of a project to develop the Asian Maize Biotechnology Network (AMBIONET). The meeting, held in 2002 in Indonesia, involved research teams from the participating countries—Indonesia, Thailand, Philippines, China (two teams), Vietnam, and India—as well as resource persons from CIMMYT headquarters and Antonio "Tony" Perez (interviewed on p. 54) from AMBIONET's primary financial supporter, the Asian Development Bank (ADB). Other significant donors include CIMMYT and the national agricultural research systems of the research teams.

Meeting National Needs through Biotechnology

AMBIONET was launched in 1998. Perez and David Hoisington, director of CIMMYT's Applied Biotechnology Center, envisioned creating a participatory forum that would employ biotechnology to catalyze increased maize productivity in Asia's developing countries. Collaboration and information sharing would advance the aims of all the teams. CIMMYT would provide technical training, backstopping, and guidance through project coordinator Maria Luz George, based in the Philippines, and scientists at CIMMYT headquarters.

The teams established research objectives to meet national and network needs. One of the objectives, the molecular profiling of maize, has already had considerable impact in China, the world's second largest maize producer, and in India, a major Asian producer. Shihuang Zhang, the AMBIONET-China country coordinator, reflects that when the network was initiated, there was considerable debate among Chinese maize breeders about pedigrees and heterotic groups. "Experienced breeders were arguing that we needed maybe 12 or 16 groups or patterns, but this was slowing progress. We went to work with the molecular markers, and today our knowledge about our materials is much better—our breeders work on the basis of 3 groups and 2 patterns, and even more important, they have changed their approach."

Prasanna tells a similar story. Indian maize breeders were skeptical about molecular genetics. Then along came the Plant Variety Protection Act. Now, says Prasanna, they are interested in fingerprinting their maize lines to firmly establish their identities: "I have more requests than my lab can handle."

Working on another AMBIONET objective, to use molecular markers to accelerate breeding for traits of interest, teams used molecular data from a cross previously mapped by CIMMYT, combined with phenotypic data produced in five locations in India, Indonesia, Philippines, and Thailand, to identify genes for downy mildew resistance. Five quantitative trait loci (QTL) that significantly influence downy mildew resistance were identified, three of which explain up to 50% of the phenotypic variance for reaction to downy mildew disease. With genetic linkage maps constructed in the AMBIONET-China lab and phenotypic data from Beijing, researchers identified five QTLs conferring resistance to sugarcane mosaic virus, explaining up to 27% of the phenotypic variance. By verifying the presence of these QTLs in their lines and varieties, breeders can be sure that they are developing plants that resist these destructive diseases.

Most gratifying for network coordinator George was simply getting the network up and running well. "Our primary goal, to form an environment where scientists could work together to apply new science to maize production, was realized, but it took some work—about 80 scientists trained at 4 workshops, 12 extended exchange visits, and contributions to 10 graduate degrees. With support from CIMMYT and the national programs, and leadership from the network scientists, we are moving forward." Team leaders discuss their experiences in "AMBIONET: Getting Students into the Lab" (see right) and "AMBIONET: Focus on Thailand," p. 53.

The funding of a second phase was an endorsement of AMBIONET's approach. "One goal for phase two," says George, "is to make the national teams and the network self-sustaining." To make this critical transition, training in grant writing has been assigned high priority. On the scientific side, genetic fingerprinting and mapping activities in support of breeding are targeted to quality protein maize (QPM), drought tolerance, genetic diversity, and resistance to banded leaf and sheath blight (an emerging threat in intensive maize/rice cropping systems). These objectives too will be supported with training, as will bioinformatics.

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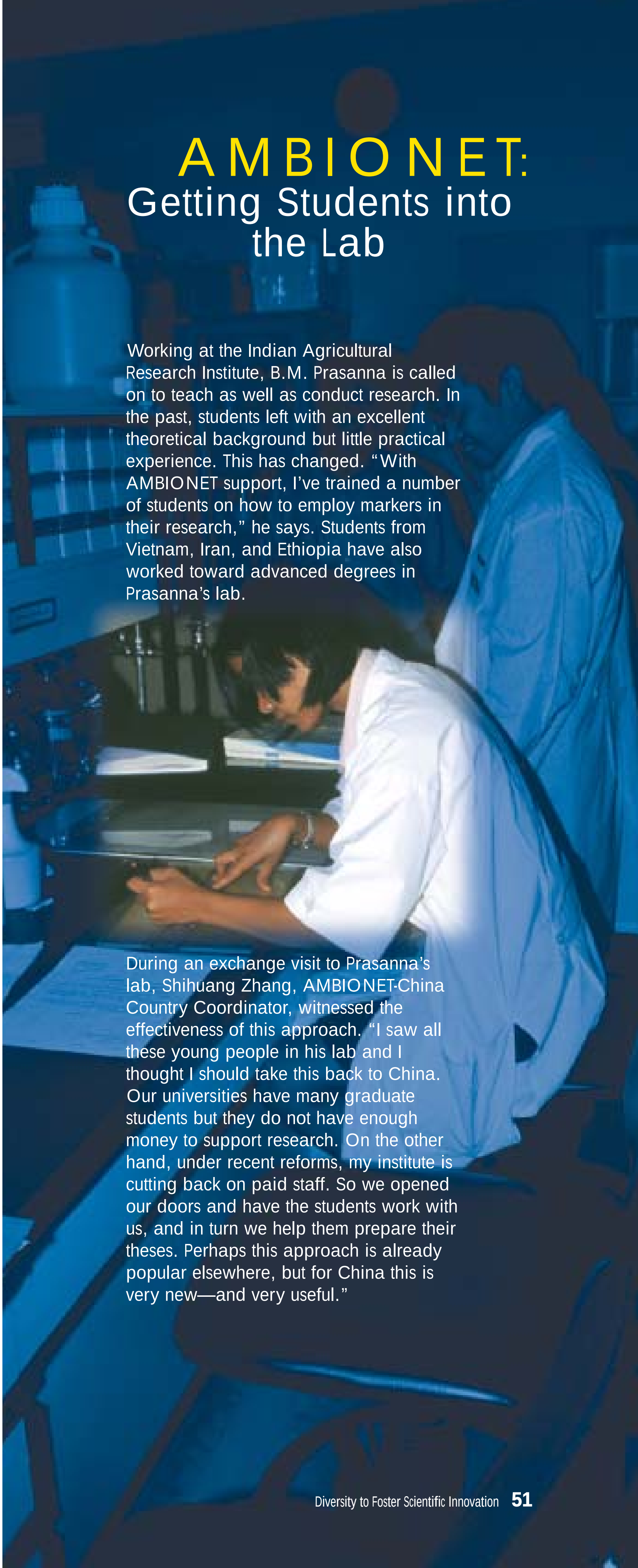

AMBIONET:
Getting Students into the Lab

Working at the Indian Agricultural Research Institute, B.M. Prasanna is called on to teach as well as conduct research. In the past, students left with an excellent theoretical background but little practical experience. This has changed. "With AMBIONET support, I've trained a number of students on how to employ markers in their research," he says. Students from Vietnam, Iran, and Ethiopia have also worked toward advanced degrees in Prasanna's lab.

During an exchange visit to Prasanna's lab, Shihuang Zhang, AMBIONET-China Country Coordinator, witnessed the effectiveness of this approach. "I saw all these young people in his lab and I thought I should take this back to China. Our universities have many graduate students but they do not have enough money to support research. On the other hand, under recent reforms, my institute is cutting back on paid staff. So we opened our doors and have the students work with us, and in turn we help them prepare their theses. Perhaps this approach is already popular elsewhere, but for China this is very new—and very useful."

As a Principal Agriculturalist with the Asian Development Bank (ADB) for many years, Antonio Perez has seen support ebb and flow for agricultural research, and he has witnessed the impacts on poor farmers. All of this has endowed Perez with a keen sense of what is needed to get results. During a break at the AMBIONET Phase II meeting in April 2002, Perez took a few moments to talk about the project with us.

A Conversation with AMBIONET Donor Representative Antonio "Tony" Perez

Q: Dr. Perez, you were present at the creation of AMBIONET. What did you originally envision?

A: What we envisioned was simply to have maize farmers benefit from biotechnology. Because the rice biotechnology network has been so successful, we found a similar opportunity to do the same with maize.

The NARS [national agricultural research systems] were not getting access to biotechnology techniques. They had laboratories, but they did not function well, if at all. Most of them were not getting support from their governments and ministries. This network was meant to build a foundation so that the scientists from the ADB developing member countries can support one another in the future.

All this ties into a central mandate of the ADB—the reduction of poverty. More than 900 million people in Asia still suffer from poverty, most of them in rural areas. We have seen firsthand how something as simple as an improved variety can make a lot of impact on the income and nutrition of the poor in these areas. When farmers earn some extra money, most often it goes to sending their children to school, a huge factor in helping people lift themselves out of poverty. Bringing biotechnology to bear on the development of improved varieties will lead to improved varieties with various resistances and advantages in terms of consumer characteristics. This is a clear route to getting the benefits of modern science to the poor farmers.

Q: Why did ADB seek out CIMMYT as a partner?

A: The advantage you gain when you bring a CGIAR center such as CIMMYT into a project is that you get a team of scientists from a range of disciplines with the knowledge to backstop the multifaceted activities of a network like AMBIONET. The ADB's focus on networks—backstopped by strong institutions such as CIMMYT—has been evaluated as one of our more successful approaches to agricultural research and development.

Q: Aside from the hard work of the AMBIONET team and CIMMYT's support, what was critical for the network's success?

A: I think those institutions that brought graduate students into their labs and programs really strengthened their outputs and the vitality of the network. They strengthened the overall scientific capacity of their nation at the same time. The lack of this approach remains a concern in some AMBIONET partners, but I believe they will move in this direction. The ADB experience is that whether it's a livestock network or a commodity network, when the universities participate, the payback in terms of quality and quantity of research are tremendous.

Q: Why did ADB decide to support a Phase II for AMBIONET?

A: Obviously we were quite pleased with the progress we saw in Phase I. The capacity building, both human and in terms of facilities, and the coalescence of the team were very encouraging. With those in place, we saw the opportunity to focus on the development of germplasm that will be tailor-made for resource-poor farmers. These are difficult but important areas of research, including resistance to drought, tolerance to low soil fertility, the introduction of quality protein maize, and resistance to emerging diseases such as banded leaf and sheath blight.

With the pool of trained people we now have in the region, we also have the ability to move into functional genomics and bioinformatics. Work in these areas can be broken down into independent components, so it is amenable to a network approach. Because of the expense and scope of this type of research, it will only be through networking that ADB developing countries will be able to fully utilize this new branch of science.

Antonio Perez, much to the regret of the AMBIONET team, retired from his position at ADB in June 2002. He plans, however, to remain active in the field of agricultural research and international development.

AMBIONET: Focus on THAILAND

Shortly after the launch of AMBIONET, Thai maize breeder Pichet Grudloyma (pictured, far right) became a key part of the Thailand team. Two years ago, he was partnered with molecular geneticist Krishnapong Sripongpankul (pictured to the left of Pichet), who works with the Asian Rice Biotechnology Network (also initiated by ADB). Krishnapong's experience with rice could be very useful in developing a marker-assisted selection approach for maize.

Both researchers concluded that they could go well beyond fingerprinting for downy mildew resistance, drought tolerance, and tolerance to low nitrogen in the soil; they could produce recombinant inbred lines that would yield a new generation of hybrids that incorporate those traits. That kind of progress goes a long way toward convincing breeders about the efficacy of the technology.

"Right now," says Pichet, "the breeders spend a lot of time and money on numerous breeding cycles. If we can optimize the marker-assisted selection, we can quickly decide whether to breed a variety further."

"We interact a lot," says Krishnapong. "Though we sit in different places and have different perspectives based on our disciplines, our idea of where we want to go is the same. We both aim to benefit farmers through the Department of Agriculture mandate. It's our job and our duty."

Such talk in a US or European lab might sound contrived. In Thailand this commitment is heartfelt, not just by the AMBIONET-Thailand team, but by the national government, which gives agriculture high priority and sees biotechnology as the way forward. In late 2002, Krishnapong will move to a new lab in the Srindhorn Plant Genetic Resources Building, named after the highly esteemed Royal Princess of Thailand who has championed the use of these technologies.

All the disciplines that use biotechnology will be in a single facility, together with a robust genebank for key crops. The facility will provide high throughput sequencing, lab and bioinformatic support for functional genomics, and with its transformation lab and biocontainment greenhouse, genetic engineering.