Connecting People to the Promise of Biotech:

Update of the ISAAA Fellowship Program
in Africa and Southeast Asia

David P. Alvarez
ISAAA and Cornell University



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Special Report: The ISAAA Fellowship Program

ISAAA Fellowships Bring Biotechnology to Southeast Asian Farmers

Update from Africa: Biotech Teams at Work

ISAAA Fellowships Bring Biotechnology to Southeast Asian Farmers

ISAAA's Private Sector Biotechnology Fellowship Program invests in people to link national agricultural institutes in developing countries with other public-sector institutes and the private-sector in industrialized countries. Awarded to researchers and policy makers from developing countries who are leaders in their fields, the Fellowships bring people face to face to exchange ideas, learn new skills, and discover mutually beneficial solutions to the hunger and poverty problems of developing countries. ISAAA Fellowships enhance the capacity of these countries to safely and effectively use biotechnology by offering advanced training in transformation techniques, intellectual property issues, commercializing products, biosafety regulations, and other core aspects of modern agricultural biotechnology.

ISAAA Fellows take an active role in learning. Visiting researchers don't read about field trials, they see them first hand to understand what the issues are. Policy makers don't listen to lectures about biosafety regulations, they work together with their hosts to write them. ISAAA Fellowships help to create the crucial personal contacts that are the foundation of genuine intellectual exchange. The program creates new possibilities between institutions by establishing new relationships between individuals. The following stories of the ISAAA Fellows at work in The Papaya Biotechnology Network of Southeast Asia *and elsewhere offer an inspiring look at their experience and its significance for bringing the benefits of biotechnology to those who need it most, the world's resource-poor farmers.*

Dr. Y.K. Chan's Answer to Papaya Ringspot Virus: Bring Biotechnology—Now!

Dr. Chan Ying Kwok, plant breeder and researcher at the Malaysian Agricultural Research and Development Institute (MARDI), looks out over the papaya field that he oversees and points to his hybrids: "This is my army." Gesturing with his arm towards the trees, he explains his work, "I breed the Malaysian Eksotika papaya with other varieties to produce new hybrids that I test against the papaya ringspot virus (PRSV)." The Eksotika papaya is Malaysia's most popular variety and the foundation for its $10 million papaya export industry. Unfortunately it is also extremely susceptible to PRSV. Dr. Chan has been fighting the virus through conventional breeding methods for many years, but has not yet found a papaya variety that can totally withstand the onslaught of PRSV.

Biotechnology was a new field for me, and I was initially skeptical about its relevance. My ISAAA Fellowship really opened my eyes to its potential.

Biotechnology, however, has given Y.K., as his fellow scientists call him, the capacity to develop a new, more powerful "army." As one of the region's leading papaya breeders, Y.K. was awarded an ISAAA Fellowship to learn about biotechnology at the University of Hawaii and at Monsanto's Life Sciences Research Center in St. Louis, Illinois. "Biotechnology was a new field for me," he states, "and I was initially skeptical about its relevance. My ISAAA Fellowship really opened my eyes to its potential."

In Hawaii, he was given an overview of the research, development, and commercialization process of the transgenic virus-resistant "Rainbow" papaya. This new variety has brought the papaya industry in Hawaii back to life, and its development serves as a model for the Papaya Biotechnology Network of Southeast Asia. He was impressed with the performance of the transgenic papayas, which he declares is "nothing short of being dramatic! As a plant breeder, it was thrilling to see how the new 'Rainbow' variety, with its virus resistant characteristics, has reinvigorated papaya breeding in Hawaii. I realized what this technology could do for my work and for our farmers in Malaysia—the Hawaiian farmers are frantic to obtain seeds for the new transgenic papaya." The success of Hawaii's transgenic "Rainbow" convinced Y.K. that biotechnology was very relevant to his work.

During his fellowship, Y.K. saw more evidence of biotechnology's promise: "I learned about rice, corn, soybean, and other crops that companies are working on. It was a very enlightening experience because you don't see well-funded corporate facilities everyday—walking through the greenhouses there I realized I was seeing agriculture's future. It was exciting and inspiring." Because of what he saw at Monsanto and Hawaii, Dr. Y.K. has since become an enthusiastic advocate for biotechnology: "I've seen the science of the future and it looks very good!"

Y.K.'s visits were designed to address the biosafety, regulatory, intellectual property, and commercialization issues related to transgenic crops. He was given practical experience in all of these areas, with a special emphasis upon biosafety. "I learned everything I needed to know about biosafety. We are ready to go. I am assisting in putting together the field trial application here at MARDI for the papayas that we are now transforming; learning about the deregulation process in the USA was extremely valuable for what we are doing here." Y.K. hopes that the knowledge gained from his experience will translate into greater public acceptance of transgenic crops in his country. "We are using the policies of the various regulatory agencies in the US as models to develop our own biosafety regulations," he explains, "and once people learn about what an exhaustive process it is—no stones were left unturned during the deregulation process of the 'Rainbow' papaya—I think that the public will no longer be so skeptical about transgenic crops."

Y.K.'s experience testifies to the efficacy of ISAAA's learning-by-doing approach. "It's like golf," he explains, "you can read books and articles about how to improve your swing, but there's no substitute for someone watching you hit the ball."

In addition to gaining experience in biosafety regulations, Y.K. also learned about intellectual property (IPR) issues. He was surprised to discover that most of the Hawaiian researchers "were of the opinion that obtaining a license from technology generators for commercial cultivation and export was even harder than getting through the deregulation process." Overcoming IPR issues is crucial for Southeast Asia's ability to participate in the benefits of biotechnology. Many of the technologies used to develop biotechnology applications are proprietary, and developing countries frequently lack the capacity in intellectual property law that would allow them to confidently negotiate IPR issues. "The help we are receiving from ISAAA regarding IPR," notes Y.K., "has been very useful. My Fellowship gave me the chance to learn about the types of provisions usually linked to license agreements, and this gives us a better sense of how these things function." (For more information about IPR issues see David Kryder's interview in ISAAA's 1997-99 Biennial Report).

Y.K. also emphasizes the importance of his close work with the scientists at Monsanto and Hawaii, which was always "hands-on." He adds, "I was able to work closely with the scientists in the USA—it was usually 'a crowd of two'—and the workshops I attended were well-structured and informative." His experience testifies to the efficacy of ISAAA's learning-by-doing approach. "It's like golf," he explains, "you can read books and articles about how to improve your swing, but there's no substitute for someone watching you hit the ball. An observer can say, 'Just do this, or adjust this'—they can easily show you what needs to be done. It's the same with science. No matter how much you read, when you sit together and share ideas then you can make rapid progress. Your projects can click." He continues, "I made a lot of friends during my ISAAA Fellowship. People were very transparent about their research—what the problems have been as well as the successes."

His first-hand experience has given him a new view of the role large companies are playing in agriculture. He notes that there is a lot of distrust about multinationals in Southeast Asia: "The corporations are seen by consumers in Asia as villains whose super varieties we will become so dependent upon that we will be at their total mercy in the future. This fear needs to be dispelled." When asked why biotech companies require licensing agreements to use their technology—even though they will not profit from the technology's use—Dr. Y. K.'s response was that a company is "not as much after the money" as it wants to ensure the "proper, responsible use of their technology. They don't want to suffer from a boomerang effect if there is a mishap that could affect their other projects." Y.K.'s fellowship is a small step towards establishing the trust that these new relationships between the private and public sectors require. ISAAA believes that by facilitating such contacts, each side will understand the concerns and needs of the other, which will allow for even more creative, exciting, and mutually advantageous relationships in the future.

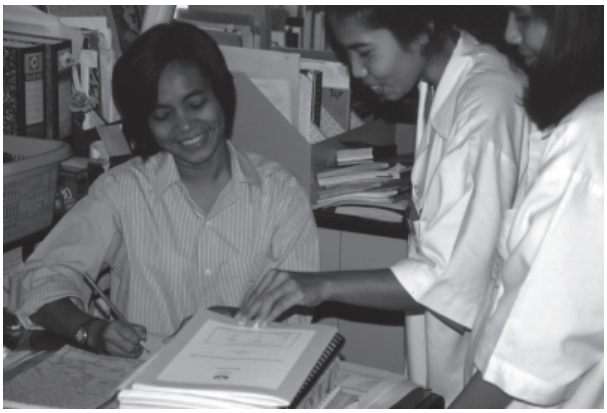
Dr. Y.K. Chan and his papaya hybrids

Perhaps it is his experience as a plant breeder that keeps Dr. Y. K. so focused on the end goal: "What I want to do is get the project rolling. Where there are obstacles, let's overcome them. I've worked as a plant breeder for many years, and when you see results like I have seen the only option is action!" He couples his "can-do" approach with

a desire to help educate the public about transgenic crops. Eager to offer science-based answers to critics of the new technology—a passion shared by many researchers involved in the Papaya Biotechnology Network of Southeast Asia—Dr. Y.K. has a straightforward message: "biotechnology is intelligent science for the public good."

Watchareewan Jamboonsri: Building Biotech and Biosafety Capacity in Thailand

Ms. Watchareewan Jamboonsri is a researcher at the Plant Genetic Engineering Unit at Kasetsart University, Thailand. Ann, as she is known at the lab, is also the Secretary of the sub-committee on plants for Thailand's National Biosafety Committee. As part of ISAAA's effort to develop closer contacts between the partners of the Papaya Biotechnology Network of Southeast Asia, Ann's ISAAA fellowship had the same itinerary as Y.K.'s. While visiting Monsanto and the University of Hawaii, they attended the same seminars together, visited the same field trials, and met the same scientists and regulators. They also gave a joint presentation on Southeast Asia's papaya industry to their hosts. Their shared experience and knowledge, which they have passed on to others in Thailand and Malaysia, has helped to strengthen the coherence of the Network's papaya project.



Ms. Watchareewan Jamboonsri instructing students at Kasetsart University, Thailand

As a biotechnology researcher and administrator working on biosafety regulations, Ann especially wanted to meet people working in these two areas: "I was really looking forward to meeting people who had been working on developing transgenic plants and who had also been involved in biosafety issues. I wanted to establish some contacts." She accomplished that and more. While at Monsanto she met with some of the company's experts on the technical, regulatory, and public acceptance issues related to a variety of transgenic crops: Bill Pilacinski on corn, Lyle Gingerich on rice and soybeans, Keith Reding on cotton, and Gary Barton and Wojciech Kaniewski on virus-resistant papaya. At the University of Hawaii, she learned about breeding programs and field tests for transgenic papaya from Richard Manshardt, delayed ripening in papaya from Kabi Neupane, papaya propagation from Maureen Fitch, and biosafety and regulatory issues from Suresh Patil, Director of the Pacific Biomedical Research Center, and Hubert Olipares, Biological Safety Officer of the University of Hawaii's Environmental Health and Safety Office. Ann remains in contact with these and other individuals she met during her ISAAA Fellowship, and she notes with satisfaction that "If I have a question, I can just write to them and ask." For example, she recently contacted Dr. Richard Manshardt at the University of Hawaii for information about the out-crossing rate of transgenic papaya in his field trials: "He was able to provide me with some useful information that has helped me design our field trials here in Thailand." Overall, the Fellowship met her expectations: "I came back with a wider and deeper understanding of both biosafety issues and the use of biotechnology applications." She also returned with a large binder full of biosafety documentation, the thickness of which suggests just how complicated her work can be.

When asked about the significance of her experience, Ann replies with an observation that every ISAAA Fellow makes: "The Fellowship gave me a sense of the real picture—it put me in contact with the actual work that is being done in other countries. I'd read and heard a lot about biotechnology and biosafety, but my visit to Hawaii and Monsanto made it concrete." As Ann's testimony makes clear, there is no substitute for bringing people together to exchange information. Not only is the learning process made more "concrete," it's also made more unpredictable—there is no way to know in advance what mutual interests will be discovered. While working with scientists at the University of Hawaii, for example, Ann learned of efforts to develop asexual propagation techniques in papaya through stem cutting. Papaya plants can be male, female, or hermaphrodite. When papaya plants reproduce, they segregate into different sexes, and so not all of them will have the same genetic material. This slows down the breeding process, since not all of the plants will possess the traits that the scientist is breeding for. Stem cutting avoids the problem of sex segregation, speeding the process of generating plants with desired characteristics by several months.

Ann found particularly useful the chance to carefully examine Monsanto's experience in deregulating transgenic crops. This process is, she notes, "a long and winding road." It has taken ten years, for example, for Monsanto to obtain approval for a variety of virus resistant potato. Such long approval periods have been common. But as US regu-

latory agencies and companies have become more familiar with the approval process, the time period required for deregulating and commercializing transgenic crops has shrunk. Hawaii's virus resistant Rainbow papaya, for example, was approved in only six years. "I'm in the process of putting together a field trial application for papaya in Thailand," Ann explains, "and my hope is that we can learn from the experience of US regulatory agencies and companies like Monsanto, who have stream-lined the deregulation process while maintaining very high safety standards. It would be a tremendous benefit for Thailand to begin with an approval process that takes 4-5 years instead of 9-10."

It's crucial to know what the farmer needs—it won't do any good to develop something in the lab that farmers don't want to grow and people don't want to eat.

In Hawaii she learned about propagating papayas through tissue culture techniques from Dr. Maureen Fitch. This is another way Ann hopes to speed up the process of developing transgenic crops: "In Thailand, we have been producing our plants via seeds, and if we use tissue culture techniques we will shave about 8 months off of the growing time for new varieties."

While visiting Monsanto's Life Sciences Research Center in St. Louis, Ann was introduced to a wide variety of advanced biotechnology projects and techniques at Monsanto. She was impressed with what she saw: "I was surprised to see natural green and brown cotton fiber! Seeing all the advanced work that Monsanto was doing gave me a sense of the possibilities, of what biotechnology will mean for agriculture."

The experience also brought home the differences. "If a scientist wants an instrument at Monsanto, he can request it and they can build it—that's just not possible here in Thailand. We don't have those kinds of resources." But these types of obstacles are precisely what the Papaya Network of Southeast Asia seeks to overcome. Ann cites Monsanto's donation of its 35S promoter, a necessary component for genetically transforming papaya, as an example of how her work has benefited from technology transfer. It is also a good example of how the ISAAA Fellowship Program facilitates such exchanges through building capacity. As Ann noted, through her fellowship she "learned a great deal about the importance of Intellectual Property Rights (IPR) in the field of agribiotechnology," and it is precisely such knowledge that makes it possible for Monsanto to comfortably transfer its technology.

Having seen the entire process of developing transgenic crops—from the lab to field trials to deregulation and commercialization—at Monsanto and the University of Hawaii, Ann was struck by the importance of including farmers in the early stages of the project. "I learned how important it is to work with the farmer from the beginning of a biotechnology project—to show them what's ahead, to get their input, and to educate them about growing transgenic crops." There may be, for example, special planting requirements for preserving a crop's resistance to pests or disease. Farmers, on the other hand, have more experience than researchers when it comes to taking care of plants in the field, and so involving farmers in field trials helps researchers assess the suitability of different varieties for "real world" deployment. Ann also notes that, "it's crucial to know what the farmer needs—it won't do any good to develop something in the lab that farmers don't want to grow and people don't want to eat." When asked about whether people would want to eat the new transgenic, virus-resistant Rainbow variety of papayas, she replies, "I tasted them when I was in Hawaii and I understand that the public's response has been great." With a smile she adds, "They were sweet and juicy!"

Dr. Parichart Burns: "Delayed Ripening Papayas in Thailand—without Delay!"

A researcher at Thailand's National Center of Genetic Engineering and Biotechnology (BIOTEC), Dr. Parichart Burns was awarded an ISAAA Fellowship to visit the University of Nottingham and Zeneca in the UK. She traveled with Dr. Umi Bakar, an ISAAA Fellow from MARDI, who is spearheading efforts in Malaysia to transform papaya

Dr. Parichart Burns and Dr. Randy Hautea

with delayed-ripening characteristics. Dr. Burns, on the other hand, has assisted in a collaborative effort between Australia and Thailand to develop PRSV resistant papayas. Thailand has a well-established transformation and regeneration system for their local papaya varieties, but at the time of Dr. Burns' fellowship it was in the early stages of cloning the gene that controls ripening: the ACC oxidase

gene. By bringing Dr. Burns and Dr. Bakar together at the University of Nottingham, which in collaboration with Zeneca has successfully transformed and marketed delayed-ripening tomato, ISAAA hoped to facilitate the rapid transfer of delayed-ripening technology to Thailand. Designed to provide a solid foundation for future collaborative efforts between countries in the Papaya Biotechnology Network of Southeast Asia, their fellowships to the UK were the Network's very first projects.

I was impressed with the importance of beginning regulatory work at the same time that you begin research.

Dr. Burns was eager to learn about delayed-ripening technology in tomato and how it could be transferred to papaya. At Nottingham University, she worked with Professor Don Grierson and his team of "very nice" post-docs, who provided her with answers to the many questions she fielded during her tours of the Plant Gene Regulation and Plant Biochemistry labs. She learned about the genes that had been linked to delayed-ripening in tomato, about the ethylene mechanisms that govern ripening, and the Yeast 2 hybrid system for cloning, all of which, she reports, has proven "very helpful" in her efforts to introduce delayed-ripening technology into papayas.

Her experience at the University also gave her the opportunity to see some of the new work in biotechnology being carried out in Professor Grierson's lab. "We were able to see what the future holds for biotechnology," she recounts, "what sort of advanced techniques are going to be available. You realize that this technology is going to change everything." Learning about the past work of the University, moreover, was just as useful: "Talking with the scientists there I quickly learned what works and what doesn't. You can ask, 'What about this?' and they can tell you yes or no—it works this way." Seeing the work being done at the University also affected her "as a scientist." She explains, "the scientific world is small, and what we are pursuing links us closely together even if we are not aware that others are pursuing the same questions. And in this small world of science things change very quickly. Scientists should recognize this and take efforts to work together more closely for the benefit of all."

I wish that more people knew about ISAAA because there is so much more that could be done.

At Zeneca, she learned about biosafety regulations, toured their glass house facilities to see first-hand the safety precautions that had been taken, and learned about the commercialization process. The latter impressed her with the importance of "beginning regulatory work at the same time that you begin doing research—getting through the regulatory process takes a long time and you want to make sure that your work will meet biosafety regulations, so you should start early." She also found it helpful at Zeneca to discuss intellectual property issues: "In Thailand, we as yet have no 'definite guidelines' about intellectual property issues, and there are four to five owners of the different constructs used in genetic transformation techniques—it's such a complicated process." She remarks that the time she spent with Dr. Camilla Beech was particularly valuable for learning about these issues, and that "it would be helpful if ISAAA could provide more information about intellectual property and biotechnology."

Her experience left Dr. Burns hungry for more information and collaboration: "It would be useful for us to continue our collaboration with the UK," she explains, "so that we can see what they have and what we have that is unique to Thailand." For example, in her discussions with Dr. Greg Tucker about delayed-ripening she also learned about research on fruit-softening that may prove useful in papaya, although fundamental research is still required to understand the precise mechanism of fruit-softening in papaya. In addition, she also learned about research on mangoes that proved to be a dead-end for UK researchers but that might be very useful for mango farmers in Thailand. She hopes that these avenues can be pursued: "We can use the experience and knowledge of our fellow scientists to our advantage—all it takes is more communication and exchange."

Dr. Burns is doing her part by teaching others in Thailand what she learned during her Fellowship: "I'm just one person, and one person can't do it all alone, but I can pass on the knowledge I gained from my time in the UK to other researchers. Working as a team we can improve papaya and other crops such as mango in the future." Dr. Burns remains in contact with some of the researchers she met at Zeneca and the University of Nottingham. She also continues to collaborate with Dr. Bakar, whom she will see again when she visits MARDI in the spring of 1999.

When asked about the progress of the papaya transformation project at BIOTEC, Dr. Burns replies enthusiastically, "It's going very well!" She is excited about the potential of *The Papaya Biotechnology Network of Southeast Asia* and would like to see ISAAA become more visible in the region: "I wish that more people knew about lSAAA; there is so much more that could be done—more people should know so that they can take advantage of what it has to offer." More certainly will be done—thanks to the efforts of scientists such as Dr. Burns, who are committed to bringing the benefits of biotechnology to the region's resource-poor farmers.

Dr. Umi Kalsom Abu Bakar: Moving Improved Papaya into Malaysia's Market

A plant molecular biologist, Dr. Umi Kalsom Abu Bakar is developing transgenic papayas with delayed-ripening characteristics in MARDI's biotechnology program. Dr. Bakar took her doctorate from Nottingham University, where she studied under Professor Don Grierson, who has worked with Zeneca to develop and market delayed-ripening tomatoes in the UK. Dr. Bakar's ISAAA Fellowship took her back to Nottingham University, where she enjoyed renewing her contacts in the UK and learning about the latest research on fruit ripening technology: "Sharing experiences and engaging in detailed discussions with the researchers at Nottingham was very useful, and what we learned will directly benefit the Papaya Network's efforts to develop transgenic papaya." Her Fellowship also included meetings at Zeneca that focused on the marketing and commercialization of transgenic crops, information that Malaysian researchers are eager to obtain. They have already made considerable progress in plant transformation techniques, but realize that successful agricultural biotechnology applications require more than successful science. What Dr. Bakar wanted most to learn from her ISAAA Fellowship was the process of product development. What does it take to move research into the market? What is the difference between developing and commercializing transgenic crops? What technologies can make the transition easier?

She was "very impressed" with her ISAAA Fellowship because things happened so quickly: "With ISAAA, it doesn't take years to implement ideas."

Dr. Bakar is keenly interested in all of these questions, and her work with Prof. Grierson and Zeneca provided her with a model for successfully developing, commercializing, and marketing a transgenic product—delayed-ripening tomato—very similar to the papayas that MARDI is transforming. She stresses the importance of this model for Malaysia's work on papaya: "Learning about product development is crucial. You have to see the whole picture from a to z in order to anticipate possible difficulties and ensure the shortest route from the lab to the market. Otherwise, your efforts in the lab might be fruitless." She is grateful for the information Prof. Grierson and the researchers at Zeneca provided. "It was very helpful," she says, "and I wish that I could have spent more time there. The facilities are impressive and there is so much going on!"

Dr. Bakar met with Dr. Rob Wilde, Research and Development Manager at Zeneca, who offered an overview of Zeneca's research strategy. "The scientific feasibility, legal issues, and potential financial returns" she learned, "are first carefully considered before any genetic engineering for crop improvement work begins." Part of this involves consumer research, observes Dr. Bakar. Surveys, for example, were taken to determine consumer preferences in Japan for a potential rice project. This is important because "the consumer's voice must be heard before a value can be placed on a new product. There must be some sense of the potential market." Once these initial questions about scientific, legal, and financial matters have been answered, a team of researchers is then set up to establish "proof-of-concept." Dr. Bakar explains, "transgenic plants are developed on a small-scale to verify the gene construct. From these plants a commercial type might be selected." She notes, however, that "the commercial variety may be very different from the 'proof-of-concept'— different promoters and selectors might be used, or you might need to move the construct into a more commercially preferred variety." This was news to Dr. Bakar, and she was happy to bring this information back to her colleagues at MARDI. "As a scientist, it is so easy to intently focus on your isolated part of the project, but without a larger vision of the process—especially of the requirements for commercial success—your own work, no matter how successful, might not make it out of your lab."

Another part of the bigger picture about biotech that the Fellowship provided was information about biosafety requirements in Europe. Dr. Bakar learned about the very strict biosafety regulations of the European Union from Dr. Camilla Beech, a Regulatory Affair's Manager at Zeneca, who is very experienced in the EU biosafety regulatory process. "These regulations are very complicated and difficult," Dr. Bakar explains, "and at MARDI we want to make sure that our transformed papayas meet EU standards; meeting with Dr. Beech was a very welcome opportunity to learn more about the

Dr. Vilasini Pilai and Dr. Umi Kalsom Abu Bakar

process." Eventually, Malaysia would like to export papayas to countries in Europe, using delayed-ripening technology to extend their shelf-life for shipping, but MARDI may have to change the gene constructs it uses to transform varieties it plans to export.

For example, MARDI currently uses a selectable marker gene to identify at a very early stage what plants have been successfully transformed with the desired gene. Scientists regularly use marker genes to avoid having to perform time-consuming DNA analyses on every single plant. The most popular method is to include in the construct used a gene that confers resistance to kanamycin, an antibiotic. When potentially transformed plants are cultured on medium that contains kanamycin, only those plants that have the kanamycin resistant gene will survive. But there are concerns about the possibility that such techniques may somehow reduce the therapeutic efficacy of antibiotics such as kanamycin. The EU's concern about this issue has led scientists in Europe to search for other selectable markers, and Dr. Bakar is very interested in their research: "It would be very beneficial to be able to use alternative marker genes to make our papaya gene constructs, since they would have been designed with biosafety approval in mind."

…the consumer's voice must be heard before a value can be placed on a new product.

The EU's labeling requirement for all transgenic food is also an important commercialization issue, since Malaysia's distribution network needs to develop the capacity to separate transgenic fruits from non-transgenic fruits. This is another example of how the transfer and development of biotechnology requires careful planning to be successful. "Malaysia has made a lot of progress in techniques to transform papayas," notes Dr. Bakar, "but bringing them to market requires more than science, and we can learn a great deal from developed countries about what else needs to be done." The information she has gained will be useful not only for papaya, but also for other future transgenic crops such as banana and mango.

In addition to obtaining information about commercializing transgenic crops, Dr. Bakar also learned about gene cloning strategies. Thre are several genes that control delayed-ripening in papaya, and Prof. Grierson's team of post-docs stressed the importance of choosing the right gene for the construct: "I learned how important targeted gene work is. You have to be careful. Many genes do similar things and you need to carefully choose the correct one." She also learned about attempts to control fruit-softening from Dr. Greg Tucker. There is very little information on delayed-softening in papaya and this technology is not a part of the Papaya Biotechnology Network of Southeast Asia, but MARDI is researching possible uses for it.

Dr. Bakar sums up her experience as a Fellow by emphasizing the role information exchange plays in producing new ideas and products: "researchers in the Network don't want to copy biotechnology applications in developed countries; they want to learn about new information and techniques so that they can build up the biotech capacity of Southeast Asian countries." This is an ongoing process for Dr. Bakar. She remains in contact with the scientists and regulators she met in the UK, asking questions and exchanging information about the technological and commercial aspects of their work. She is happy to have had the opportunity to make these connections. The Fellowship also came at a very welcome time for her research. Due to the economic crisis afflicting Southeast Asia, research travel funds have dried up, making external funding essential. Above all, she is pleased to see the Papaya Network quickly moving forward. She was "very impressed" with her ISAAA Fellowship because things happened so quickly: "With ISAAA, it doesn't take years to implement ideas. The Papaya Network was set up in March 1998 and I arrived in the UK in August of the same year."

Dr. Umi Bakar assisting Lam Dai Nhan with labwork at MARDI

Vietnamese Fellows Lam Dai Nhan and Nguyen Huy Hoang: Partnerships for Success within Southeast Asia

The Papaya Biotechnology Network of Southeast Asia seeks to foster learning and technology exchange not only between developing and developed countries but also between the various Southeast Asian countries participating in the Network. Each of these countries has different strengths. In Malaysia, for example, MARDI has already cloned the ACC oxidase gene for delayed ripening and has a strong genetic transformation program. To spread these benefits, ISAAA has sponsored two Fellows from

Vietnam's Institute of Plant Breeding (IPB), Mr. Lam Dai Nhan and Mr. Nguyen Huy Hoang, to study Vietnamese papaya at MARDI.

Both fellows are excited about the work they are able to do here. Mr. Hoang has cloned the ACC oxidase gene from ripe Vietnamese papaya fruit using the RT-PCR method and is in the process of making an antisense gene construct for the ACC oxidase gene. These are big steps towards producing delayed-ripening papayas in Vietnam. "Learning these new techniques has been the most interesting part of the Fellowship for me" states Mr. Hoang, "and thanks to the support of our hosts, we have been able to accomplish much in a short time." MARDI's Dr. Umi Bakar, another ISAAA Fellow, is supervising their work. She reports that the Fellows are "making good progress" learning new techniques to express genes, check genotypes, and clone genes using the RT-PCR method.

Mr. Nhan is pursuing research on PRSV-resistance in Vietnamese papayas: "The work is going very well. I'm getting good results comparing the structure of PRSV here in Malaysia with that from Vietnam; we are checking to see if we can use the coat protein that MARDI has or whether we need a different coat protein to protect papaya in Vietnam." Working with the "new machines" at MARDI has allowed him to gather important data and to learn new techniques that he is "eager to take back to Vietnam." Both Fellows appreciate the experience and are enjoying the new friends they have made. "Everyone has been so helpful and kind here," Mr. Hoang enthusiastically states, "and I hope our collaboration can continue."

Ms. Lolita Valencia: Energized for Biotechnology

The ISAAA Fellows are carefully chosen to enhance the overall strength of the Network, and, like the countries they represent, each ISAAA Fellow comes with different strengths, approaches, and outlooks. Certainly one of the most enthusiastic and energetic of the ISAAA Fellows working within the Papaya Biotechnology Network of Southeast Asia is Ms. Lolita Valencia of the Philippines' Institute for Plant Breeding (IPB). Given her commitment to halting the spread of PRSV, it sounds somewhat inappropriate to call her excitement "infectious," but it is. And by spending just a few moments with Ms. Valencia you can learn that there is a lot to be excited about.

A plant breeder and plant pathologist at IPB, Ms. Valencia's ISAAA Fellowship took her to Thailand, where she worked at Kasetsart University's Plant Genetic Engineering Unit (PGEU). She was able to spend three months learning about the biotechnology techniques that the PGEU is using to transform Thailand's papayas: cloning, molecular characterization, handling a particle gun, tissue culture, initiating somatic embryos, and other essential techniques. Before her Fellowship, Ms. Valencia had not done much work in biotechnology, and she was apprehensive about learning all the new material. "I was a little nervous because I didn't have any previous experience in biotechnology," she explains, "but I said to myself 'Oh, I can do it!'" And she did. She plunged right in and got to work. "It took patience and practice," she adds, "but I knew I needed to work hard to learn and absorb all the information." She attributes the success of the program to her "excellent teachers": Dr. Supat Attathom, Dr. Orawan Chatchawankanphanich, Dr.Kanokwan Kanokwaree, and Dr. Thomas Burns.

Ms. Valencia brought back from Thailand not only new skills and knowledge but also important components for the Philippines' own efforts to combat PRSV. She was able to clone and characterize the viral coat protein of PRSV from RNA samples she had taken with her to Thailand, and when she returned to the Philippines she brought back the isolate of her analysis.

Lolita Valencia displaying her prize: the PCB-LBP vector construct

Her greatest accomplishment, however, was the completion of her vector construct: the PCP-LBP (Plasmid Coat Protein—Los Baños, the Philippines). This is a big step forward for the PRSV resistance project at IPB, which is quickly moving to meet the challenge of PRSV in the Philippines.

Ms. Valencia explains that the virus has reached epidemic levels in the Philippines. "All local and foreign papaya strains are susceptible to PRSV, and the plants can get infected during any stage of growth," she explains. Killing the plants it infects, the virus devastates whole farms and makes "papaya growing unprofitable." In some areas the papaya production area has been cut in half, raising papaya prices beyond the reach of ordinary families. This has also reduced the income of farmers, since papaya is an important cash crop for small-holders. The IPB has under-

taken research to develop PRSV-tolerant varieties of papaya and is working to educate farmers about growing strategies that can reduce the damage the virus causes to their crops, but Ms. Valencia thinks that the best hope for papaya farmers in the Philippines is the development of transgenic PRSV-resistant papaya. "This is how the problem has been solved in developed countries," she observes, "and I think that we can solve the PRSV problem for our farmers here in the same way. I'm happy to have had the chance to learn about the new technology through the ISAAA Fellowship."

Overall, Ms. Valencia's experience was "a great one." She considers the Fellowship a turning point in her own career as a plant scientist and has since shifted her work in the Philippines to focus more on biotechnology. This

Transgenic virus resistance is a much more potent technology than conventionally breeding for tolerance.

semester she enrolled in biotechnology courses at the University of the Philippines, Los Baños. When asked what excites her about biotechnology and what motivated this change in her studies, she cites four reasons. First, the training she received in Thailand inspired her to learn more. "My trainers were very generous and helpful," she says, "and I think I caught some of their enthusiasm about their own work." Second, the papayas produced through biotechnology will be resistant to PRSV: "it's a much more potent technology than conventionally breeding for tolerance, which is really only a stop-gap measure that has to be combined with other disease management strategies to make an impact. Transgenic papayas that are resistant to PRSV will solve the problem for our farmers once and for all." Third, her experience in Thailand opened her eyes to the potential of biotechnology not just for papaya but for other crops as well. "I'm very curious about what new applications can be developed in the Philippines using biotechnology," she explains. Finally, as a plant breeder she is impressed with the speed of biotechnology, with how quickly new varieties can be developed and tested: "there's no need to wait for the plants to grow because we can know through selectable markers exactly what genes have been introduced into the plants. Biotech is fast and that is what we need."

Ms. Valencia is busy these days learning more about the science behind biotechnology, sharing the information and techniques she acquired during her Fellowship, and tending her tissue culture papaya plantlets. All of her work is sprouting with promise.

Indonesian Fellows Diani Damayanti and Eri Sofiari: Partnerships for Success within Southeast Asia

"Papaya is becoming more and more important for Indonesia—but unfortunately so is PRSV," reports Eri Sofiari of Indonesia's Central Research Institute for Horticulture. As part of the effort to foster information and technology exchange between Network countries, Eri Sofiari and Diani Damayanti were awarded ISAAA Fellowships to travel to Kasetsart University in Thailand, where considerable progress has been made in developing PRSV-resistant papayas. "We arrived on October 26, 1998," Diani recalls, "and started work right away—there was a lot to learn."

Diani Damayanti

"We learned many biotechnology procedures required for tissue culture, papaya transformation, and PRSV resistance screening," states Eri, "but frankly it was isolating and cloning the coat protein of PRSV, which was tedious and very complicated work, that was the most interesting. This is the topic that I was looking forward to studying most." The coat protein that Eri and Diani cloned was from an Indonesian strain of PRSV found in Bangor. They brought back the construct of the coat protein to Indonesia, where it will be used to develop transgenic papayas that are specifically resistant to Indonesian strains of PRSV.

"I liked that I wasn't only gaining knowledge but was practicing skills," explains Diani. She worked with the particle gun to practice particle bombardment and gained experience working with RT-PCR and Elisa techniques to identify PRSV. Both Fellows enjoyed working with their Thai hosts and they were very pleased to have had the opportunity to study at Kasetsart University. "I know that there is so much that I still don't know about biotechnology," Eri states, "and that developed countries have done even more with gene cloning and its application to important crops than we realize, but I believe that through collaborative research efforts like this we can rapidly improve our ability in Southeast Asia to use biotechnology. We just need more collaborative projects."

"I liked that I wasn't only gaining knowledge but was practicing skills," explains Diani.

Dr. Eduardo Fernandez: Biosafety Management in The Philippines

Dr. Eduardo Fernandez, Deputy Director and Researcher at the University of the Philippines' Institute of Plant Breeding in Los Baños (IPB), was awarded an ISAAA Fellowship to learn about biosafety regulations and procedures in the United States and Canada. Dr. Fernandez knew exactly what he wanted from his fellowship experience: "I wanted first-hand knowledge about handling transgenic crops, particularly about applying for and managing field trials." Although one of the first countries in Southeast Asia to develop a biosafety system, the Philippines has only recently approved field testing guidelines for genetically modified organisms (GMOs).

Dr. Eduardo Fernandez at Cargill Hybrid Seeds, USA

After his return from the Fellowship, Dr. Fernandez assisted in putting together the field trial application for *Bt* corn, which has been a slow process because of the strict guidelines that must be followed. "The National Committee on Biosafety is cautious about approving biotech research proposals," he explains, "but what I learned through the ISAAA Fellowship has enabled us to move the process forward more quickly." Dr. Fernandez knows how much farmers need this technology. Through its educational seminars and workshops on new plant varieties, the IPB has a strong relationship with the farmers it serves. Dr. Fernandez had recently participated in a seminar in the southern Philippines, where the farmers had one question for him that he heard again and again: "When are we going to be able to plant *Bt* corn?" Dr. Fernandez explains, "The corn borer is causing terrible problems in this area of the Philippines. The crops are being consumed by these insects and farmers have no options. Pesticides are not effective anymore."Fernandez puts the point plainly, "If you listen to the farmers, the question is not should we use biotechnology to protect crops, but when!"

In talking to Dr. Fernandez you gain a quick sense of his priorities. He keeps his eye on the practical effects of his research and on the farmer who will benefit from his work. His approach to biosafety is equally concrete: "In the US and Canada I saw that there were thousands of acres of transgenic crops being grown—I wanted to know what needed to be done to bring the benefits of biotech here." The ISAAA fellowship gave him the opportunity to learn about biosafety review committees and regulatory procedures in the USA and Canada by meeting with officials from the USDA's Animal and Plant Health Inspection Agency (APHIS), the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), Cargill Hybrid Seeds, the Canadian Food Inspection Agency (CFIA), and other Canadian biosafety groups. Fernandez found it very helpful to talk to other scientists, regulators, and administrators face to face: "I gained a broader view of the regulatory process by talking to those who had worked their way through it. You can only learn so much from a book or report, and these scientists and public officials gave me information that I would not have found until a problem appeared in the application. Learning first-hand about how to put together a field-trial application has saved so much time." How much time? Dr. Fernandez estimates that several months have been shaved off the application process: "We can put together an effective application more quickly because we know what to look for; we know what a good field trial application requires."

His most valuable experience as an ISAAA Felllow was reviewing an application for non-regulated status of a variety of Round-Up Ready Canola with the APHIS/USDA Biotechnology Team: "I was impressed with the thoroughness of the review, and my hands-on experience working over there on the application has been very useful for me here putting together an integrated field trial application for *Bt* corn." He also learned about the structure of the North American regulatory systems, which divide the review process into distinct areas overseen by different regulatory agencies. By meeting with regulators from each of the agencies, Dr. Fernandez was able to look at the problem of biosafety from several different angles—food safety, environmental impact, pesticide risk, and others—to gain a fuller understanding of the regulatory processes in the USA and Canada.

Dr. Fernandez met with scientists and managers on both sides of the public/private sector divide: "We had good discussions with the biotech group at the USDA, where we went over analyses and case studies of field trials that had previously been approved to see what worked—you gain a much broader perspective and you can zero in on what the critical concerns are when you can discuss the applications

In the US and Canada I saw that there were millions of acres of transgenic crops being grown—I wanted to know what needed to be done to bring the benefits of biotech here.

with the reviewers." Seeing the other side of the regulatory process was equally valuable: "It was useful to see how Cargill Hybrid Seeds complied with the US regulations, and it was very clear how important a good, strong relationship between the regulator and the applicant is—there must be mutual trust."

Dr. Fernandez was also interested in what biosafety regulations in the US and Canada focus on. He emphasizes the fact that "the regulating agencies do not treat biotechnology as only a threat—they see its potential—so there is a balance between biosafety concerns and a desire to make biotech work, which is the sort of spirit to approach these issues with." He noted the importance of the close coordination on biosafety between the US and Canada for the technology's quick acceptance, and he hopes that the Papaya Network will contribute to the harmonization of Southeast Asian biosafety regulations and produce similar effects. Other ideas that affected his thinking about biosafety were "the countries' focus on the product and not the process" of biotechnology. Food safety evaluations are based on the "substantial equivalence" of transgenic foods to their non-transgenic counterparts, which is where he thinks the focus should be.

… what became clear to me is how essential it is for the regulatory agencies to have the public's trust—regulations and biotechnology research have to be transparent to the public.

There's definitely a future for biotech in the Philippines—for the farmers here it can't come soon enough.

Above all, he observes, "what became clear to me is how essential it is for the regulatory agencies to have the public's trust—regulations and biotechnology research have to be transparent to the public." He connected the successful planting of the thousands of acres of transgenic crops in the USA and Canada to the public's faith in their regulatory agencies, and in the Philippines he is eagerly working with other national agencies to educate the public about biotechnology.

Dr. Fernandez also saw that agricultural practices in the US and Canada were very different from the practices of the Philippines. Not everything can "simply be adopted" because the cultural differences are too great. Farms in the Philippines, for example, are much smaller than those in the US and Canada, and Philippino farmers usually grow several types of crops on their plots. Managing for *Bt* resistance and developing isolation requirements will require, therefore, different approaches than those in North America. Still, notes Fernandez, "we gained very valuable information about these problems, and when their solutions could not be our solutions, they served as a catalyst for our own thinking about these issues."

The Fellowship has given Dr. Fernandez greater confidence in the Philippines' own ability to proceed with agribiotechnology projects. He has seen what biotechnology can do and he knows what can be done with it in the Philippines: "We should not be satisfied to remain only consumers of Western biotechnology because we are capable of producing our own." As part of this ongoing work, Dr. Fernandez remains in contact with the administrators and scientists he met during his visits as an ISAAA Fellow. Recently, USDA officials also visited the Philippines, which was an opportune time to renew acquaintances.

The knowledge Fernandez gained in the USA and Canada about biosafety regulations and field trial applications not only benefits the ongoing papaya project but also the proposed field trials for the *Bt* corn that farmers in the Philippines are eagerly waiting for. He can guide the application through regulatory channels more quickly, anticipate problems, and educate the public about this new biotechnology application. Fernandez explains, "With this information I've been able to confidently communicate to others about the benefits of biotechnology and assist in developing research strategies that will improve our crops and help our farmers." Improved varieties of other important crops in the Philippines, such as mango, coconut, and banana, are on the drawing board. "There's definitely a future for biotech in the Philippines," Fernandez proclaims, "and for the farmers here it can't come soon enough."

Dr. Emerenciana Duran and "The Multiplier Effect"

Dr. Emerenciana Duran is a member of the Philippines' National Committee on Biosafety and Officer-in-Charge at the Atomic Research Division of the Philippine Nuclear Research Institute. An influential advisor on national biosafety policies in the Philippines, Dr. Duran is grateful to have had the opportunity to further her education about biosafety regulations in the USA and Canada through the ISAAA Biotechnology Fellowship Program. "ISAAA has been a leader in trying to promote the safe use of biotechnology in this region," she states, "and I was very pleased to be a part of this process. This visit to the USA and Canada constituted a quantum leap for me in terms of my abilities as a member of the National Biosafety Committee of the Philippines." Dr. Duran particularly values "the in-depth learning" and "insight" she gained into "the science and phi-

This visit constituted a quantum leap for me…

losophy underlying the regulatory policies of these countries." She believes that what set her Fellowship experience apart from the many seminars and conferences she has attended was its emphasis on active learning: "We participated in activities at the agencies we visited—we were not just passively receiving information—and that made it possible to learn so much more."

Dr. Emerenciana Duran

As Dr. Duran quickly explains, she is a big believer in education's "multiplier effect." After returning to the Philippines, she wasted no time in passing on to others the knowledge she had gained from her Fellowship. She is finishing up work on two biosafety educational projects, both of which seek to enhance the region's ability to safely use biotechnology. First, she is contributing a chapter to a forthcoming book on biosafety published by ISNAR (International Service for National Agricultural Research). The chapter, entitled "Formulating Guidelines for Field Testing: Management Challenges in Agribiotechnology," offers an overview of the structure and history of the Philippines' biosafety system, with an emphasis on managing field trials. She hopes that sharing her country's experience in developing biosafety regulations will benefit other countries embarking on the same task: "We should all work together to make the best use of our limited resources in expertise and infrastructure to avoid needlessly re-inventing the wheel." With support from ISAAA and in collaboration with Patricia Traynor of the Intermediary Biotechnology Service, Dr. Duran's second project has been to develop a series of training modules on monitoring and regulating biotechnology applications and products. She plans to run a course based on the modules this year. "Education can change attitudes," she steadfastly declares, "and I believe it is necessary to be more pro-active, not reactive, in informing people about the risks and benefits of genetically modified products." Finally, Dr. Duran is also pushing to place more information on the World Wide Web site of the Philippine National Biosafety Committee, a move that she hopes will make its decisions and proceedings more transparent to the public.

I believe it is necessary to be more pro-active, not reactive, in informing people about the risks and benefits of genetically modified products.

There is much educational work that needs to be done in the Philippines, where NGO sentiments against the use of biotechnology have permeated the public consciousness and influenced politicians. There are bills pending in the Philippine Congress that would severely restrict the use of genetically modified organisms (GMOs), and while these bills are not expected to pass, Dr. Duran has been hard at work educating members of Congress about biotechnology. She comments that the ISAAA Fellowship was fortuitously timed, since soon after her return she met with cabinet officials to discuss biosafety issues and was able to share what she had recently seen and learned. She is straightforward about discussing biotechnology: "Members of the National Biosafety Committee must be capable—they must have a firm grasp on the issues involved—and they must be transparent and worth the public's trust. The goal should always be to provide science-based information. This is a very effective way to address specific questions and to focus discussions on particular issues instead of general anxieties about GMOs." She notes in an aside, "The ISAAA Briefs are quite helpful in this regard."

Her experience as an ISAAA Fellow gave her access to virtually another world of advanced "science-based information." She and Dr. Fernandez had the same itinerary, traveling to various regulatory agencies in the USA and Canada and also to Cargill Hybrid Seeds. This last stop gave her pause, for at first she had some misgivings about visiting a private business engaged in biotechnology. As a member of the Philippine National Biosafety Committee, she did not want to give even the appearance of impropriety in visiting Cargill Hybrid Seeds. She wanted to make sure that no one would think her unduly influenced by business interests in a field she regulates. The solution to this difficulty highlights the unique position that ISAAA plays in the transfer of agribiotechnology. ISAAA acts as an honest broker, an intermediary between national institutes and private companies that allows for new exchanges of technologies and ideas. Dr. Duran's visit was not sponsored by Cargill Hybrid Seeds but by ISAAA, who has no business interest in biotechnology. As an ISAAA Fellow, Dr. Duran realized that she would not be exposed to potential conflicts of interest. And she was glad she saw Cargill's facilities. Her visit there allowed her to see the biosafety review process from the view of the developer, and she also saw first-hand how the company managed *Bt* insect-resistance risks and prevented outcrossing in their seed production. Dr. Duran comments, "Since our national institutes are as interested in developing new biotechnology applications as Cargill is, the visit provided very useful information."

Dr Duran also found the review of Round-Up Ready Canola for non-regulated status a particularly rewarding experience. "We individually reviewed the petition," she explains, "and then met with the APHIS reviewers to compare notes on the results of our evaluation." Working through the review on her own required her to grapple with fundamental biosafety issues: "The actual practice of regulating biotechnology is a very different experience from attending a seminar. The review required us to identify risks and ask if they were being properly managed. We had to give an answer to the question of 'What should be done?'" In addition to learning about regulatory procedures and field trial management in the USA, Dr. Duran also found Canada's approach, with its somewhat more conservative guidelines based on the notion of "substantial equivalence" between transgenic and non-transgenic foods a useful model for analyzing the food safety of commercial biotech applications.

When addressing the public's concerns about biotechnology, the goal should always be to provide science-based information.

She describes her fellowship experience as "crucial" for her representation of the Philippines at an ASEAN meeting held in January 1999 on developing harmonized biosafety regulations for Southeast Asia. "Thanks in part to what I had learned through the Fellowship, the Philippines were able to significantly contribute to the meeting; in particular, we assisted in developing a draft of harmonized guidelines that will be presented to senior officials in April." Harmonizing biosafety regulations creates important advantages for countries in Asia. First, countries without a regulatory system can adopt these rules or use them as guidelines to create their own. Second, harmonizing regulations also opens up the countries to one another: "There was a level of scrutiny about technological capacity and plans for trade" Dr. Duran points out, "that improved trust and cooperation." Third, harmonization will make it easier for countries in Southeast Asia to export transgenic crops to one another and possibly to Europe and North America. Finally, harmonizing these regulations makes sense because the climate and farming practices are similar throughout the region. As Dr. Duran discovered, there is a greater contrast of farming practices within the USA than within those countries that make up the ASEAN.

Dr. Duran is grateful for ISAAA's assistance with biosafety issues and she is excited about the new *SEAsia*Center: "Dr. Hautea has already been helpful in identifying agricultural needs in the region that biotechnology can meet, and having a specialized center that caters to the needs of Southeast Asia will certainly enable the use of new biotechnology applications for the benefit of our growing populations." Conditions in Southeast Asia are very different from those in the developed world, and the impact of biotechnology will likewise be very different. Dr. Duran explains that "in this region biotechnology will make a direct impact on food sufficiency and security—it will help reduce hunger and poverty." She also believes that ISAAA's dissemination of "science-based information" will hasten the arrival of biotechnology's benefits to Southeast Asia. She especially feels that her Fellowship has made it possible for her to do more about educating the public: "Personally, I really appreciate these opportunities, which other organizations would not have provided. I learned so much." One thing is certain: the knowledge Dr. Duran has gained from her ISAAA Fellowship will not stop with her.

Papaya Trees in Malaysia

Update from Africa: Biotech Teams at Work

ISAAA's 1996 Annual Report, "Advancing Altruism in Africa," focused on our African biotechnology projects. Much has happened since that report was written, and so we offer the following update on the progress being made in Africa through the safe, efficient use of agricultural biotechnology applications. The banana project in particular has met with even more success than we anticipated, and a detailed, independent socio-economic study of the project's benefits is now available (ISAAA Briefs #10, Assessing the Impact of Banana Biotechnology in Kenya*). Here we offer a sketch of our projects by following the stories of our ISAAA Fellows in Africa. Our update seeks to give a sense of the real people working on ISAAA's projects, the local leaders who are putting biotech in the hands of Africa's subsistence farmers.*

ISAAA's fellowship program offers biotechnology training to potential leaders for efforts in Africa, Southeast Asia, and Latin America. For although agricultural biotechnology is relatively simple for a farmer to use, any project is complex, and a core of well trained, local professionals are essential for its success. Thanks to those who have generously supported these fellowship programs, ISAAA, working in conjunction with national research and educational institutions, has helped to establish leadership teams in Africa. These teams are working now to propagate multi-purpose trees and banana plantlets and to analyze the genes of viruses that attack maize and sweet potatoes.

A Core Team to Promote Kenyan Agroforestry: Pauline Mbubu, Professor Joe Mwangi, and Muraya Minjire

Ms. Pauline Mbabu faced quite a challenge. She had no previous experience in tissue culture propagation techniques, yet she needed to master this complicated process in just 10 short months. "I knew I had a lot to learn," recalled Pauline, "and I was both anxious and excited about the training." Inspired by the importance of her studies for Kenya's future tissue culture laboratory, and energized by the prospect of a new career, Pauline was determined to succeed. She packed her bags and books, and for the first time in her life left Kenya to study abroad at Natal University in South Africa.

Project leader Joe Mwangi, FHMC Kenya, discusses the multipurpose tree project with ISAAA team members and Lawrence Cockcroft of the Gatsby Charitable Foundation

Pauline is one of three staff members of Kenya's Forestry Health and Management Center (FHMC) who have received specialized training in South Africa through ISAAA's fellowship program. These three individuals are critical to successfully implementing an ISAAA-brokered project that will dramatically increase the multiplication and dissemination of important tree species in Kenya.

This project uses both propagation from conventional macro-cuttings and from tissue culture parent stock to provide Kenyan farmers with what they urgently need: a greatly expanded supply of planting materials to meet the country's runaway demand for multi-purpose tree products. Kenyans need wood to cook their food, and fuel is becoming more and more scarce. FHMC is up-scaling its laboratory operations, expanding its main nursery, and establishing a network of regional nurseries as part of the project. The species selected as priorities for widespread dissemination are Kenya's most popular multipurpose tree species, *Grevillea robusta*, an Australian hardwood species that can be used for carving, *Acacia melanoxylon,* and several Eucalyptus species useful for firewood. While the *grevillea* and *acacia* materials are Kenyan, the Eucalyptus materials come partly from South Africa and partly from Kenya.

Successful projects require successful team leaders, and while Prof. Joe Mwangi wouldn't want to say that he *blazed* the trail for this forestry project, he did lead the way. He was the first FHMC staff member to visit South Africa and analyze whether educational exchanges such as Pauline's would be beneficial. His visit was crucial, since as the manager of FHMC the project would not have gone forward without his approval. He wanted to make sure that the project would be relevant to Kenya's needs. Joe had already developed the use of tissue culture and macrocutting technology in his experimental work on *Grevillea*

robusta, but he had no experience in its commercial application. He knew that up-scaling to millions of seedlings per year would present difficulties because of the sensitivity of the tissue culture process, yet to make an impact in Kenya the large-scale production of millions of seedlings was exactly what was required.

> *"I saw that clonal technology…could greatly reduce the amount of time it takes to get high-quality seedlings into the hands of the farmers who need them."*
> *—Prof. Joe Mwangi*

So in 1996 Joe visited Mondi Forests, a division of the international pulp and paper manufacturer Mondi Limited. Mondi Forests manages a large Eucalyptus estate in South Africa's Natal Province near Kwambonambi. The company has its own tissue culture laboratory and nursery, which produce disease-free planting materials for the estate and conduct research on new Eucalyptus clones and hybrids. Overall, Mondi Forest owns about three-quarter million hectares of Eucalyptus and processes about one million tons of pulp each year.

Barry Herman examines a Eucalyptus plantlet at Mondi Forests, South Africa

Joe spent a month at Kwambonambi, where he gained a better general understanding of the use of tissue culture and the processes required for its mass propagation and commercial application. He appreciated the potential of Mondi Forests' techniques: "I saw that if we introduced clonal technology into Kenya, then we could greatly reduce the amount of time it takes to get high-quality seedlings into the hands of the farmers who need them. Used by itself, the normal process of propagating through cuttings is far too slow." Joe also appreciated the detailed hands-on experience he gained from his time at Mondi: "Working closely in the laboratory and nursery, I learned how macro-propagation combined with micro-propagation increases both the quantity and the quality of the seedlings." On his return he gave the project his blessing and promptly began its implementation: "I came back convinced the process could work for Kenya."

Pauline's training, which culminated in a BSc honours degree at Natal University in South Africa, was one of the first steps in implementing the project. Her education was designed to enable her to play a pivotal role in the project. After all, she was to take charge of all of the tissue culture operations in FHMC's newly refurbished laboratory. For her BSc she took four courses, one of which consisted of an industrial internship, and another of which was on plant biotechnology that included a special project on the micro-propagation of *Acacia melanoxylon*.

The internship was at Mondi Forests, where Pauline spent 7 weeks getting hands-on experience with all aspects of tissue culture—including a special emphasis on rooting techniques that is the basis for the efficient production of tree seedlings. "I now understand the process from start to finish," says Pauline. "We covered everything from callus formation through to hardening and planting out a clonal hedge."

The special project was particularly important because the mass propagation and dissemination of *Acacia melanoxylon* could prove vital to the future of Kenya's carving industry. Since it can be used as a substitute for threatened species such as ebony, the new trees could help save the country's biodiversity. Pauline tested two different micro-propagation methods, one from shoots and the other from nodal cuttings. The most productive method was the use of nodal cuttings, so Pauline has decided to use it when efforts to upscale lab production start next year.

After her education, Pauline flew back to Kenya and returned to FHMC, where she was promoted to the position of biotechnologist and assumed responsibility for the laboratory. Currently, she is organizing and equipping the lab in preparation for scaling up production. She is looking forward to running FHMC's own full-scale tissue culture program with great anticipation: "I'm eager to share what I have learned in South Africa with my co-workers here at the lab—we can make a lot of progress!" She acknowledges that the team faces significant challenges, but she also knows she won't be on her own when she has questions: both of her hosts in South Africa have offered continuing support in the months to come through telephone, fax, e-mail, and occasional visits.

Pauline's most important colleague at FHMC is head nurseryman Muraya Minjire. Muraya joined FHMC in 1993 as a lab technician. In 1996 he was sent to Kwambonambi nursery for training in the skills that would equip him for his new post. Muraya's training covered all aspects of

nursery management, with a special emphasis on conventional macro-propagation from cuttings. This is just as highly skilled a procedure as tissue culture in the laboratory. "Everything must be carefully controlled at each step of the operation," Muraya observes. Indeed, cuttings are highly sensitive to changes in temperature, moisture, and nutrient conditions, all of which must be tightly managed.

Tissue cultured bananas planted in the field

As FHMC steps up its operations, macro-propagation will increasingly be used in conjunction with micro-propagation because, as Joe observed, this improves both the quantity and quality of the seedlings. Pauline will send rooted clones developed in the laboratory to Muraya for conventional reproduction in the nursery. Working with Joe, Pauline and Muraya will be crucial to FHMC's ability to supply farmers with top-quality planting materials. To this end, they are also training other local staff to assist with the project as it expands. By helping to build a core team of skilled staff at FHMC, ISAAA's fellowship program has made a vital contribution to the future of agroforestry in Kenya.

Transferring Expertise in Banana Tissue Culture: Joel Mutisya and Margaret Onyango

Bananas are the number one priority at Kenya's National Horticultural Research Centre (NHRC). That's not surprising since the crop is a valuable staple food and income earner for millions of farmers in Kenya and elsewhere in Eastern Africa. But the orchards that produce the fruit are badly in need of rejuvenation, having recently come under increasing attack from pests and diseases.

Tissue culture offers a low-cost way to rapidly multiply and disseminate the new planting materials farmers need. Successfully applied to banana production in South Africa, so far the technique has had limited application elsewhere on the continent. In 1996, ISAAA began developing a project that would harness South Africa's expertise in this field in order to build national capacity for banana tissue culture in Eastern Africa, starting in Kenya. The project also sought to introduce tissue-cultured plantlets to farmers and to strengthen plantlet distribution channels.

Based at Thika in one of Kenya's three major banana-growing regions, the NHRC is the project's primary national public-sector partner. Part of the Kenya Agricultural Research Institute (KARI), it also conducts banana research at several other regional centres.

Among the NHRC staff trained under the project is horticulturist Joel Mutisya, who had earned a BSc in agriculture at the University of Nairobi and a MSc in horticulture at Canada's University of Guelph before joining the team at Thika. Joel's first contact with ISAAA came in 1996, when he met Florence Wambugu, Director of ISAAA's *Afri*Centre, who was visiting Thika to plan the banana project. In May 1997, thanks to an ISAAA fellowship, Joel was on his way to South Africa for training at the Institute of Tropical and Subtropical Crops (ITSC). This institute, now recognized throughout Africa for its expertise in banana tissue culture, has paved the way for the profitable export trade in banana plantlets engaged in by several South African companies today.

"It was the best place to learn what I needed to know about banana tissue culture—and I learned a lot," Joel states matter-of-factly. His training program at ITSC prepared him for the post he now occupies: officer-in-charge of the multiplication of plantlets in the Thika laboratory.

The crucial first step in tissue culture is selecting the right cultivars, the plants and suckers that will provide the raw material for mass propagation. Kenya is rich in banana cultivars, but few of them have been researched in any detailed way. Joel is keen to explore and exploit this diversity. "The potential is so rich," he notes. While at ITSC he learned how to evaluate cultivars by asking consumers to score them for their taste and acceptability, and he learned about the criteria for selecting individual plants for multiplication on a trial basis. He also gained experience in conducting field evaluations of tissue-cultured plantlets, studying the persistence of traits such as bunch size, shape, and time to maturity.

"Farmers are very interested in these plants, and we want to make sure that their introduction is a success."
—Margaret Onyango

Joel cites his training in sucker selection as one of the most valuable experiences of his trip. "The skills of sucker

selection are little known in Kenya," he says. "I was taught that suckers facing the rising sun and growing on the uphill side of the plant are stronger, but here I was shown how to select three suckers and then, at the right time, to narrow the choice down to one only." Since his return to Kenya Joel has passed his new knowledge about sucker selection to on-farm researchers, who will convey it to the farming community.

Strict quality control in the laboratory is absolutely essential for the successful propagation of large amounts of healthy planting material. At ITSC, Joel learned about the protocols used for multiplying different cultivars. The most sensitive part of the operation is producing the media used to stimulate germination and promote growth. Skill is needed to identify exactly the right mix of growth hormones, vitamins, and sugars.

Field trial of tissue cultured bananas

Now back in the lab at Thika, Joel has lost no time in putting his newly developed skills into practice. He says the project to upscale production is going well. And thanks to further support under the ISAAA project, he now has an expanded growth room with enough space for large quantities of plantlets in the several different varieties he wants to grow and provide to farmers.

Meanwhile, at another KARI regional research centre, Margaret Onyango is also putting into practice the skills she recently acquired in South Africa. Margaret is a research officer at the Kisii Center near Lake Victoria in western Kenya, which is the heart of the country's second major banana growing area. Margaret's work puts her in daily contact with the banana farmers who will use the plantlets she is helping to develop. Currently responsible for several on-farm trials of banana plantlets raised in a private-sector laboratory in Nairobi, she is demonstrating to local farmers the benefits of tissue-culture bananas. "The farmers are very interested in these plants," she explains, "and we want to make sure that their introduction is a success." Part of Margaret's role is to teach farmers how to obtain the best results when transplanting plantlets into their fields.

While in South Africa, Margaret visited ITSC and also DuRoi, a firm that exports plantlets to Kenya through another private biotech laboratory, Genetic Technology Limited (GTL). These visits provided her with an overview of the tissue culture process—from the initiation of callus formation in the laboratory to the planting of the young tree on the farm. Here she gained a background for more detailed studies at ITSC, where she also acquired techniques in handling plantlets at the hardening stage and in nursery management, both of which she needed to take back to Kisii.

At present, the laboratory supplies soil-potted plantlets at a relatively advanced stage of growth in order to ensure successful planting. But this makes them bulky and expensive to transport, which increases the cost to farmers. One aim of ISAAA's project, therefore, was to "decentralize" the skills needed to bring the plants to this stage. The transition from laboratory test tube to a potted plant capable of surviving out of doors is a delicate one that requires gradual acclimatization. Margaret learned how to transfer the rooted plantlets from tubes to pots, and she also learned how to store the plantlets, first in mist chambers and then under shade in the open. This knowledge will help her supply farmers in the Kisii area with viable plants at lower prices.

Margaret also studied the agronomic techniques required to raise tissue-cultured plantlets into healthy and productive trees. Effectively applying these techniques is vital when working with plantlets, and farmers must learn to manage their new plantations more intensively than in the traditional system. To bring out the best in the new materials it is essential to clean the field thoroughly before planting, observe the correct planting density, apply fertilizer in the right amounts and at the right times, and make that sure the young trees receive enough water.

This knowledge is enriching Margaret's on-farm research in the Kisii area. Both the participating farmers and visiting groups from surrounding areas are now able to see for themselves the advantages of tissue-cultured plants. Margaret says that the new plants have already excited a great deal of interest, which she plans to build on by increasing the number of field days and farmers' visits during the coming seasons. She recognizes that the price of these new materials will be a critical factor in whether or not farmers opt to adopt them. But Margaret is confident that small-scale farmers will be prepared to pay for the new planting materials once nursery operations are decentralized to Kisii. "I know they will," she says with a smile, "because they have seen that the new trees produce more and better fruit."

A Better Understanding of Maize Streak Virus: Drs. Jackson Njuguna, Benjamin Odhiambo, John Wafula

When Jackson Njuguna started research on maize streak virus (MSV) in 1989, he didn't do so out of idle academic curiosity. Although its presence had not been very serious in Kenya, in 1988 the disease suddenly struck the country's most important food crop with devastating force—in the worst affected areas yields had been reduced to near zero. KARI responded promptly to the emergency by re-assigning its two pathologists, Jackson and his colleague Benjamin Odhiambo, to work on the problem.

The researchers quickly learned that the best source of expertise on maize streak in Africa was the University of Cape Town, which had been studying the disease since it was first recorded in 1901. In the 1980s, university scientists had begun using the tools of modern biotechnology to better understand the virus' most potent weapon against attempts to control it genetically—its variability. Populations of the virus that had been collected in South Africa and Zimbabwe were analyzed. By examining DNA sequences using restriction fragment length polymorphisms (RFLPs), the scientists at the University possessed a very useful catalogue of virus variants based on their discoveries of similarities and differences between isolates gathered from different areas.

African farmers need answers to maize streak virus (MSV)

In 1996 ISAAA launched a multi-partner project to tackle the MSV problem in Eastern and Southern Africa. The strategy was to develop a package of control measures, the centrepiece of which was to accurately target resistant varieties to the specific areas that would benefit from their use. During project planning, Florence Wambugu approached KARI's biotechnology co-ordinator, Dr John Wafula, to ask how ISAAA could help advance Kenya's understanding of the variability of the pathogen. She suggested that ISAAA could help link KARI's pathologists with scientists at the University of Cape Town. Dr. Wafula observed that Jackson and his colleagues had already identified the three main areas in Kenya affected by the disease and had also collected isolates from each of them. They had found considerable diversity, within areas as well as between them.

In the worst affected areas maize yields have been reduced to near zero.

Wafula agreed that now was the time to build on these findings by applying the biotechnological tools successfully used at the university. The Rockefeller Foundation generously agreed to fund a trip to South Africa for Jackson and Odhiambo through the ISAAA fellowship program.

The trip exposed both researchers to the use of RFLPs for the first time. And so, in addition to shedding light on an important national problem, their time at the University of Cape Town was also an opportunity to build biotechnology research capacity within KARI. The analyses conducted by the Kenyans and their South African colleagues showed that the streak isolates present in Kenya differ greatly from those of South Africa but that they are fairly similar to isolates from Zimbabwe. This has important implications for screening and breeding for resistance to the disease. The Centro Internacional de Mejoramiento de Maizy Trigo (CIMMYT), which has a program in Zimbabwe, has worked with national researchers to develop a new generation of immune materials based on germplasm collected locally. These materials can be expected to do well in parts of Kenya. In fact, initial trials at Githunguri, a hot spot in the Kenyan highlands, have revealed that several CIMMYT lines produce reasonable yields in the presence of maize streak disease.

The benefits of this discovery were particularly heartening for Jackson and Odhiambo. "The experience has shown that it is really possible to make advances through selection and breeding," says Jackson. "That gives us new hope in the struggle against this devastating disease."

Towards Kenya's First Genetically Modified Sweet Potato: Dr. Duncan Kirubi

"It's a great challenge," says Duncan Kirubi, "and I feel really fulfilled." Duncan is referring to his part in a pioneering project to raise the productivity of sweet potato in Kenya and neighboring countries through the use of genetic engineering. A partnership between the public and private sectors in the developing and developed world, the project links Kenya's national agricultural research institute (KARI) with the well-known US-based multinational Monsanto. The technology deployed in the project has been generously donated by Monsanto, which is also partly funding the project.

Sweet potatoes and other root and tuber crops on sale

Sweet potato is a high-yielding, drought-resistant crop grown by millions of resource-poor farmers in Eastern Africa. In recent years it has become increasingly susceptible to complexes of viral diseases that have caused catastrophic declines in yields. Within most of these complexes lurks the sweet potato feathery mottle virus (SPFMV), which causes no serious losses itself but is lethal in combination with other viruses.

Transmitted by aphids, the virus causes a wide range of symptoms, which makes it difficult to identify it with certainty in the field. Sometimes plants merely carry the virus and display no symptoms at all. For these reasons, conventional approaches to breeding for resistance have failed to deliver solutions. In the early 1990s, KARI became convinced that biotechnology offered the only hope for moving forward.

With funding from the United States Agency for International Development (USAID), KARI scientists worked at Monsanto to develop transgenic sweet potato varieties resistant to SPFMV. To ensure that the final product would be acceptable to consumers, eight improved varieties already grown by Kenyan farmers were used as the raw materials for transformation.

Under an ISAAA fellowship, Duncan, who holds a PhD in genetic engineering, went to Monsanto to take responsibility for the crucial second phase of the project, which involves checking to ensure that the resistance genes are present and are being effectively expressed. Duncan is challenging the transformed varieties with both US and Kenyan strains of the virus, which are thought to be more virulent. If the transgenic plants pass these two tests, they will be taken back to Kenya and tested against Kenyan strains in field trials.

The team at Monsanto has been left in no doubt as to Duncan's commitment to the job, and they have responded by giving him a warm welcome and extra support. Joining together with KARI and ISAAA, Duncan's wife and daughter were able to travel from Kenya to accompany him, and he has also been lent a car to make getting about in his temporary hometown easier. "Everyone has been so friendly and helpful here," says Duncan with a smile. "It's been great to work with such a great team."

Meanwhile, back in Kenya, Florence Wambugu is working with KARI's staff to obtain government permits for re-importing the modified plants. The plants' imminent arrival is serving as a catalyst for the established National Biosafety Committee (NBC) to draw up biosafety regulations. In preparation for field testing, scientists at KARI have conducted mock-trials using non-transgenic plants. The purpose of these trials is to demonstrate KARI's ability to handle transgenics and to trouble-shoot any possible problems. Besides developing a product that will contribute greatly to food production and income generation, the project is also building Kenya's capacity to absorb and deploy biotechnology.

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