Feed the Future Innovation Lab for IPM

A Decade of Innovation

2004 – 2014

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IPM Innovation Lab
Feed the Future Innovation Lab for
Integrated Pest Management

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IPM: Advancing agriculture into the future

The concept of integrated pest management is an old one. Early farmers couldn't have known that such things as viruses or bacteria were attacking their crops, but they did the best they could. Ancient Egyptians and Sumerians used herbs and oils to control insect pests. In the 1100s, Chinese discovered that soap worked to defend plants against nefarious insects.

Then, in the 20th century, along came the discovery of chemical pesticides. While they at first seemed like a panacea, people soon learned of the potentially harmful effects of using heavy doses of these compounds in an inefficient manner. By the 1950s, scientists had discovered that some insects had even developed high levels of pesticide resistance. The time was ripe for a new approach, and so was born the modern concept of integrated pest management: a holistic system that uses a suite of techniques that help farmers produce high volumes of healthful crops in a sustainable, environmentally friendly manner.

The result of applying IPM principles has been astounding. Around the world, livelihoods have been restored and farmer incomes increased, allowing parents to send their children to school and to buy nutritious food. In southern India, papaya farmers have seen the destruction of the papaya mealybug pest; in Bangladesh, the introduction of grafting has allowed farmers to grow eggplant that resists the devastating scourge of bacterial wilt; and in West Africa, the "host-free" technique of growing tomatoes has meant that farmers can again grow this commercially valuable crop in an environment prone to high levels of white fly infestation.

These life-changing interventions have all occurred over the past 10 years. An economic study published in the *Journal of Crop Protection* showed that one intervention alone—the destruction of the papaya mealybug in India via biological control—represented $1.34 billion in savings.

On my trips throughout the world to monitor the progress of this program, as I sit with men and women in farmer cooperatives, walk into tomato fields and cabbage patches bursting with beautiful produce, and attend workshops on invasive species, I have seen the smiles on farmer's faces, the excitement of a local scientist who reports a major discovery, and the laughter of well-fed children.

This is why I am so proud of the work that we, the United States Agency for International Development, allied with all our partners around the world, are doing. We could have no better partner than Virginia Tech to lead this effort, no better partnering universities and research organizations in the United States and around the world, and no better scientists, students, and extension agents in our target countries.

This is why I am confident that we can meet the challenge of feeding the world's growing population. This is why I look forward to the next five year phase (2014-2019) of the IPM Innovation Lab with eagerness, optimism, and high expectations.

— John E. Bowman, Ph.D.
Plant Pathologist/USAID Program Area Leader for Nutritious and Safe Foods/USAID Agreement Officer's Representative (AOR) for the IPM Innovation Lab

Feed the Future Innovation Lab for IPM: A Decade of Innovation

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Table of Contents

Dr. Muniappan, director of the IPM Innovation Lab, takes a picture of a banana plant showing signs of banana leaf roller damage.

IPM Innovation Lab: Ten years of success, innovation, and collaboration

Integrated pest management makes sense. It allows farmers to protect their crops from pests and diseases without heavily investing in toxic pesticides and suffering from the environmental and health costs that inevitably ensue.

As the director of the Feed the Future Integrated Pest Management Innovation Lab (IPM IL) at Virginia Tech, I am proud to be part of a program that works to spread IPM techniques among smallholder farming communities in developing countries. Over the past ten years, we've operated in numerous countries and in six different regions of the tropical world, working with farmers, researchers, extension agents, government officials, students, and others to fight some of the most devastating scourges that have swept across the hot, flat, crowded places of the earth.

Pests respect no boundaries—they don't ask permission to cross a country's borders like humans do. But they have travelled with us, making themselves comfortable in the absence of natural predators that kept their populations in check back home.

The rise of global trade and climate change has exacerbated this issue, and poor farming families bear the brunt of the burden, having too few resources to fend off the destructive and unfamiliar pests.

Farming families in India are trying to protect their crops from a South American moth; Ecuadorian fruit growers must move their crop seasonally to avoid disease while the land beneath them erodes; Ethiopian farmers tackle a noxious weed that swamps their fields, crowding out crops and native plants; and the list goes on.

The vision

Traditional methods of pest and disease control, which include heavy applications of dangerous chemicals, are cost prohibitive and increasingly ineffective for smallholder farmers. The mission of the IPM Innovation Lab is to offer practical, safer alternatives.

We implement participatory farmer-focused research and training that can be adopted and adapted for horticultural crops and other food production systems in developing countries.

Over the past decade, the project aimed to reduce crop loss, increase farmer income, reduce pesticide use, improve IPM research and education, improve pest monitoring, and increase the involvement of women in IPM decision-making and program design.

To achieve this vision, the IPM Innovation Lab approach involved networking, private sector involvement, technology development, and technology transfer.

The program's success relied upon the ability of researchers and collaborators to develop IPM techniques—such as grafting, mulching, and biological control—and then bundle them into packages targeted to specific crops, regions, seasons, and problems.

During the past ten years, the program worked in the following countries:

- **West Africa:** Ghana, Mali, and Senegal
- **East Africa:** Ethiopia, Kenya, Tanzania, and Uganda
- **Eastern Europe:** Albania, Moldova, and Ukraine
- **Central Asia:** Kyrgyzstan, Tajikistan, and Uzbekistan
- **South Asia:** Bangladesh, India, and Nepal
- **Southeast Asia:** Cambodia, Indonesia, and the Philippines
- **Latin America and the Caribbean:** Dominican Republic, Ecuador, Guatemala, and Honduras

Investing in people

Cross-cutting projects on virus diseases, diagnostics, gender, and impact assessment were implemented in all regions. The management of the invasive weed parthenium was implemented in Ethiopia, Kenya, Tanzania, and Uganda. Additionally, several invasive species, including the papaya mealybug, the Asian cycad scale, and the South American tomato leafminer were recorded in participating host countries.

We have prioritized education and technology transfer by conducting frequent IPM workshops on specialized topics such as *Trichoderma*, *Metarhizium*, *Beauveria*, *Pseudomonas fluorescens*, *Tuta absoluta*, papaya mealybug, and seed-borne virus diseases. Some of the workshops involved South-South technology transfer, which means they were both led and attended by scientists from developing countries. Through these workshops and other educational endeavors, millions of people received short-term training, and more than 250 candidates received graduate training,

We've been raising awareness about the research and impact of the IPM IL at symposia during annual meetings of the Entomological Society of America, the American Phytopathological Society, the American Society for Horticultural Sciences, the Meso-American IPM Congress, the 7th and 8th International IPM Symposia, and others. Our program was awarded the International IPM Excellence Award in 2009 by the IPM Symposium.

But the most important accolade has been how our work has been received by farmers themselves in developing countries. The IPM techniques we've demonstrated and taught have spread organically from village to village, region to region, and, in some cases, from country to country. IPM methods save money, protect the environment, mitigate pest and disease damage, and improve livelihoods—people recognize a good thing when they see it.

This publication offers just a taste of the positive impact the Integrated Pest Management Innovation Lab has had on the lives of people all over the world.

– R. Muniappan
Director, IPM Innovation Lab

Halting crop destruction in India

The tiny wasps were released on a hot day in the summer of 2010 in papaya orchards at strategic locations throughout southern India. Their mission? To attack and destroy a nasty infestation of the papaya mealybug that had wrought havoc in orchards throughout the south Asian country, threatening the livelihoods of thousands of farmers.

The parasitic wasps had travelled all the way from Puerto Rico—carried by hand, and accompanied by special letters of transport ensuring that they wouldn't have to go through airport x-ray machines. They were propagated at 57 locations in the south Indian state of Tamil Nadu in preparation for being released.

Papaya is a million-dollar business in India. The fruit is grown not just to be eaten, but also for papain, a substance it contains. This substance is used in the making of chewing gum, shampoo, toothpaste, and tooth whiteners. It is also used as a meat tenderizer and in the brewing and textile industries. The destruction of thousands of acres of papaya trees due to the papaya mealybug meant that many farmers would be without a means of supporting their families.

This would not do. Muni Muniappan, program director of the IPM Innovation Lab, had made the discovery of the papaya mealybug in India in 2008. He recommended to the Indian government that they import parasitic wasps raised by the U.S. Department of Agriculture in Puerto Rico. But there were delays. The import approval process stalled in the halls of government while the insect jumped from orchard to orchard, covering ever more swaths of southern India.

Finally, in 2010, approval for the release of the parasitic wasps was granted. Under a partnership that included several U.S. and Indian government agencies, scientists released the imported wasp.

Results were dramatic. By February of 2011, orchards were free of the pest. Farmers could again grow the economically important crop of papaya. In a study published in the *Journal of Crop Protection*, agricultural economist George Norton stated that this intervention represented a savings of $524 million to $1.34 billion over five years.

"The important thing is that the papaya farmers of India can now return to the work that gives them such great satisfaction," said Muniappan.

Speckled beetle key to saving crops in Ethiopia

An invasive weed poses a serious problem for farming families in Ethiopia, but scientists from the IPM Innovation Lab have unleashed a new weapon in the fight against hunger: a tiny, speckled beetle.

The weed, called parthenium, is so destructive that farmers in the east African nation have despairingly given it the nickname "faramsissa" in Amharic, which, translated, means "sign your land away." After a decade-long effort, scientists from the IPM Innovation Lab released a parthenium-eating beetle called *Zygogramma bicolorata.*

In the early 1970s, parthenium entered Ethiopia by accident. With nothing to check its spread, this toxic weed has become the second most common weed in Ethiopia, suppressing the growth of all other plants, wreaking havoc on smallholder farms, and poisoning the animals who eat it.

The Innovation Lab built a quarantine facility in 2007 to ensure that the pea-sized beetle had eyes for parthenium alone. Testing under quarantine is one of the crucial steps involved in biological control, a rigorously tested method where an invasive species' natural enemies are used to regulate it.

After a laborious process, *Z. bicolorata* was approved for release. Researchers and collaborators constructed a breeding facility and increased the beetle population. Finally, on July 16, 2014, the Innovation Lab team, under the direction of Virginia State University scientist Wondi Mersie, joined a group of scientists and farmers in Wollenchiti, Ethiopia, to release the insects. The group moved from parthenium patch to parthenium patch, dumping beetles from containers.

Ethiopian researchers are monitoring the sites and assessing the impact. As a second step, scientists are poised to release a stem-boring weevil that will join *Zygogramma,* but even these measures will not eliminate parthenium from Ethiopian farmland.

However, if an integrated pest management strategy is established for parthenium in Ethiopia, it will ease the burden on smallholder farmers, reducing the need for hand-weeding and the rashes that come from parthenium contact, reducing the amount of pesticide used, and contributing to food security in the region.

An integrated strategy has to start somewhere, and a Tupperware full of tiny, speckled beetles is a good first step.

Invasion of the tomato leafminer

For the past eight years, scientists from the IPM Innovation Lab have been chasing a tiny invasive moth as it has ravaged its way through many European, North African, and Mediterranean countries. *Tuta absoluta*, a.k.a. the South American tomato leafminer, is an insect no larger than an eyelash, which can decimate 80 to 100 percent of a tomato farmer's yield. A native of South America, the moth was accidently introduced to Spain in 2006. In November of last year, researchers found it infesting tomato crops in India. Now it's only a matter of time before the storm of tiny jaws hits Nepal and Bangladesh.

How do you fight a diminutive, hungry moth? Even though South Asian agricultural officials are on high alert, *Tuta absoluta* cannot be stopped. But there are a number of sustainable measures that have been used to control *Tuta* in other countries. They include pheromone traps, biological and plant-based insecticides, and using the pest's own natural enemies against it.

The first and greatest hurdle is a general lack of information. Farmers don't necessarily know what's whittling away at their crops or how to defend themselves against it. The IPM Innovation Lab has been hosting workshops throughout Africa and South Asia in order to increase public awareness and help growers first identify *Tuta absoluta* and then combat it.

"If this information reaches farmers before the pest does, they will have the ammunition they need to fight it," said IPM Innovation Lab director Muni Muniappan.

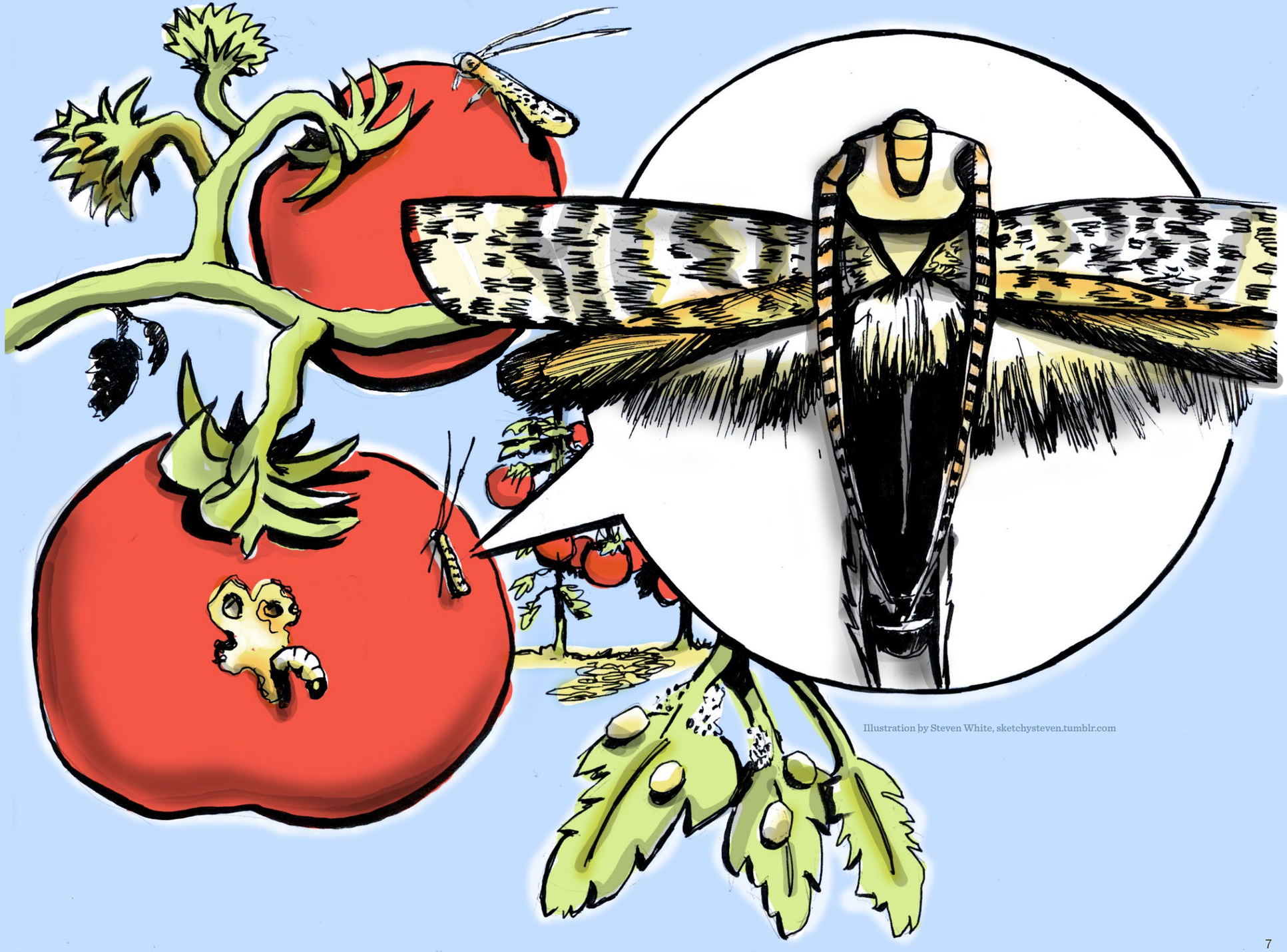


Illustration by Steven White, sketchysteven.tumblr.com

IPM "PACKAGES"

refer to a suite of techniques that are optimized for a certain crop, and that allows farmers to address pests and diseases without over-relying on chemical pesticides.

The IPM Innovation Lab has developed IPM packages for bitter gourd, cabbage, cauliflower, eggplant, naranjilla, okra, onion, pointed gourd, potato, pumpkin, and tomato.

The program focuses on teaching farmers and extension agents in developing countries about these techniques at field days, workshops, meetings, and through mass media.

IPM package for tomato

Preparing the soil

Soil solarization and fertilization combined with compost mixed with neem cake and beneficial fungi improves a plant's nutrition and equips it to defend itself from pests.

Selecting healthy seed

Selecting clean, local, disease-tolerant varieties of tomato will protect the crop from seed-borne and other diseases.

Treating seeds

Treating seeds with a beneficial fungus and bacterium protects seedlings from fungal, bacterial, and nematode attacks and increases seedling vigor.

Caring for seedlings

Tactics for good seedbed preparation include using coconut dust as a planting medium in plastic trays to prevent soil-borne diseases; using screens to ward off virus-carrying insect pests; and preventing excess moisture, which can increase the severity of fungal diseases.

Fertilizing and Roguing

Neem and mustard oil cakes alone or combined with beneficial fungi can reduce the number of nematodes in the soil and build up the supply of beneficial microbes. Farmers are also encouraged to dispose of infected plants to prevent disease spread.

Grafting

Grafting high-yielding tomato scions onto disease-resistant rootstock will keep vulnerable plants free from soil-borne diseases.

Host-free period

Keeping an area free of susceptible crops for three months before planting reduces the incidence of *Tomato yellow leaf curl virus* transmitted by the whitefly.

Staking and mulching

Staking exposes plants to air and sunlight, and prevents shoots and fruits from touching the soil, which reduces late blight infection and fruit rot. Mulching conserves moisture and reduces pests.

Sticky traps and pheromone traps

Yellow sticky traps in the field can reduce pest populations, while pheromone traps reduce populations of the tomato fruit worm *Helicoverpa armigera* and the army worm *Spodoptera litura*.

Microbial control

The beneficial use of some viruses, fungi, and nematodes can control whiteflies, caterpillars, and thrips. These biopesticides may eliminate the use of synthetic pesticides.

Biological control

Biocontrol is a rigorously tested method where an invasive species' natural enemies are used to regulate it.

Taming zebra chip disease

Zebra-chipped potatoes display a zebra-striped pattern, giving them their name. An uninfected potato (left) next to an infected potato (right).

Zebra chip, a quick-moving plant disease, has been plaguing potato farmers in southwestern United States and Central America, rendering their crops unsellable.

Potatoes affected by zebra chip display a zebra stripe pattern after being sliced and fried. The disease also breaks the potato's starch down to sugar, which gives the vegetable a bad taste.

Scientists working on zebra chip have identified a major culprit in this infestation—an insect called the potato psyllid—which looks like a tiny cicada. Researchers believe that while the insect is busy feasting, it transmits a bacterium, *Candidatus* Liberibacter, to the potato plant. Adding this pathogen to the mix amplifies the damage. Once the plant has been infected, it will most likely develop zebra chip. When solanaceous crops—like tomato, pepper, or eggplant—are infected with *Candidatus* Liberibacter, they fail to ripen properly, and, in some cases, die.

In Honduras, IPM researchers conducted field trials and research on the severity of the disease. They looked into how to breed a more resistant variety. The team also developed best practices for growers.

A demonstration plot in Honduras showcased sanitation procedures for equipment, and researchers encouraged farmers to spray for the psyllid when they first arrived, as opposed to over-spraying throughout the season. Farmers were taught to destroy the infected plants as opposed to abandoning them, reducing the chances that zebra chip disease would spread to neighboring fields.

Once researchers develop an IPM package to control the spread of zebra chip, they plan to disseminate the information to farmers in Honduras and beyond. This will help ensure the future of a staple crop for growers and the survival of an industry.

IPM scientists combat cacao pest in Ecuador

Rachel Melnick learned one thing about spending long days in Ecuadoran cacao orchards: Do not work past 4:00 p.m. “Once, we made the mistake of working past 4:00 p.m. in the field. We quickly realized why no one did this—that is when all of the mosquitoes come out!”

Working with Penn State plant pathologist Paul Backman on the IPM Innovation Lab project, Melnick, a graduate student, studied how to use beneficial bacteria to fight diseases that attack cacao trees.

The cacao tree, of course, is the plant from which we get cocoa, the foundational component of chocolate. And chocolate is big business in Ecuador and becoming more so by the day.

However, a serious pest has wreaked havoc with cocoa production in Ecuador in recent years. Witches’ broom, or *Moniliophthora perniciosa*, is a fungal disease that has devastated the cacao industry in Latin America. Since its arrival in Ecuador, witches’ broom has catastrophically affected cacao production—reducing output by 50 to 90 percent.

Melnick and Backman have used biological control agents—an environmentally sound way to reduce pests—to control the intruder. “I sprayed the bacteria onto the cacao trees, allowing the bacteria to colonize the internal tissue of the tree. From there, it could be a natural enemy to the fungal diseases,” Melnick says. One advantage of the bacteria is its robustness, allowing it to be effective through Ecuador’s rainy season.

The research has been successful so far. It has resulted in locally appropriate methods that can be used by both large and small-scale farms. Furthermore, results have surfaced from other IPM trials showing that intercropping cacao with plantain reduced diseases on both crops and reduced nematodes (microscopic roundworms) that were attacking plantain.

Melnick, the key researcher on this project, has completed her Ph.D. and now works as a national program leader at the U.S. Department of Agriculture, where she continues to research biological control of the diseases of cacao. And where she now works past 4:00 p.m.

A helpful host-free period

Virus diseases transmitted by insects are a big problem for developing country farmers. *Tomato yellow leaf curl virus*, carried by the whitefly, is a disease that alone causes millions of dollars of damage to smallholder farmers. But one technique has proven particularly helpful in combating this virus disease—the "host-free period."

What exactly is a host-free period?

Insects feed on plants—the "host." If you remove target host plants from a location, *although the insect may remain in the area*, the incidence of virus in the locale decreases sharply. For example, a farmer may stop growing tomato and pepper, but grow beans instead, for a season. When the farmer resumes growing tomato or pepper after the host-free period, the plants will have a head start on a healthy, virus-free life.

In temperate regions, winter provides a natural host-free period, allowing crops planted anew in the spring to have a jump start on viruses. But farmers in warmer regions grow crops year-round, so a host-free period of two to three months can be a valuable weapon against a number of whitefly-transmitted viruses.

Why would host-free periods be effective against whitefly-transmitted viruses?

High whitefly populations and crop infections can lead to yield losses as high as 100%. In some cases, susceptible crops can no longer be grown in areas where virus pressure is high. The host-free period can be effective because these viruses are not seed-transmitted, whiteflies have short life cycles, and viruses can't be transmitted through whitefly eggs to the next generation.

How did this all come about?

Bob Gilbertson, a scientist with the IPM Innovation Lab, initiated the practice in Mali in tomato and pepper fields. Farmers noticed that with the technique, yields were much higher than before, during virus outbreaks. An economic impact study performed by agricultural economists confirmed the results: Benefits were estimated to be between $21–24 million.

A tough row to hoe: Virginia Tech programs partner to improve potato production in Ecuador

The potato is often described as a "humble" root—grubby and plebian. But potato is the fifth most important crop worldwide. It grows quickly and uses less water than most other workhorse crops.

Working high in the Andes, Virginia Tech scientists, in partnership with researchers from Ecuador's National Institute for Agriculture Research (INIAP), are helping farmers sustainably grow this staple in the face of threats from climate change, erosion, and invasive species.

The IPM Innovation Lab and the Sustainable Agriculture and Natural Resource Management (SANREM) Innovation Lab pooled their expertise and began working with five families to grow healthier, more resilient crops.

An IPM Innovation Lab regional program, led by agricultural economist Jeff Alwang, developed a suite of techniques for crops that decrease the use of chemical pesticides while increasing crop yields and improving the environment, human health, and gender situations. The integrated programs apply their techniques to all phases of potato production—preparing the soil, planting, and harvesting. The project trains farmers to preserve soil structure, plant native shrubs and grasses to protect the topsoil, and rotate crops so that the land will have time to recover. When it's time to sow the seed potatoes, farmers treat them with a beneficial fungus called *Trichoderma* that controls soil-borne fungal diseases.

But securing and nourishing the soil is only half the battle. Although the potato has other pests, the Andean potato weevil is the most destructive of the pests and diseases that plague Ecuadorian potato farmers. The weevil crawls through soil from neighboring fields to feed on potato plants and bore into the tubers. But the pest is unable to fly, so the program promotes a simple, effective way to combat it: digging a trench around the crop. The weevils fall into the trench and can't mount the battlement of the ditch.

A plant needs sun, nutrients, water, and time to grow. Modern agriculture practices often have disparate approaches to each of these needs. But as farmers and researchers move into a more comprehensive understanding of evolving ecosystems, they are finding wisdom in synthesis.

Seeding success in southern India

In southern India, farmers have found a new use for coconut dust.

The material, part of the husk of a coconut, used to wind up on the side of roads, often becoming a fire hazard. But in 2007, scientists with the Integrated Pest Management Innovation Lab, working with universities in India, began disseminating the technique of using coconut pith in seedling trays to germinate seeds.

“Soil-grown seedlings are normally not very healthy, and almost 50 percent of them are lost to diseases,” says Muni Muniappan, director of the IPM Innovation Lab. Soil carries bacterial and fungal diseases, so plants grown in soil are susceptible to these threats. “But when a seedling is healthy, you can as much as double the yield.”

Coconut dust provides an ideal medium in which to grow young seedlings until they’re ready to be transplanted. Their lightweight cellulosic structure allows the roots of a seed to establish themselves and at the same time absorb just the right amount of water. Furthermore, when “coco-peat” is added to soil, it improves the soil’s texture and structure. Sandy soil becomes more compact, and clayey soil becomes more arable. And importantly, the medium is more likely to be free from pathogenic bacteria and fungi.

The practice of using coconut dust in seedling trays has led to the growth of nurseries. “Where farmers used to grow their own seedlings, now they buy them from nurseries, a healthier option,” says S. Mohankumar, professor of entomology at Tamil Nadu Agricultural University, and a partner on the project. “In this way,” Muniappan explains, “we have helped spur private sector development at the same time that we are helping farmers produce better crops.”

Frequencies for farmers: IPM training over the airwaves

Radios are a dwindling presence in American homes, and the sound of static—much like the clicking of typewriters or a dial-up connection—threatens to be erased from collective memory. But for people in developing countries, analog radio is a powerful medium for communication. Subscriptions are not required, and the cost of small, handheld receivers is low.

In India, farm programming from All India Radio (AIR) serves a vast rural audience, many of whom depend on its daily weather, planting, and pest and disease updates.

Scientists with the IPM Innovation Lab and Tamil Nadu Agricultural University organized a 20-week radio series on IPM methods. Farm School Radio, as it was called by organizers, reached hundreds—and likely thousands—of farmers in Tamil Nadu on three AIR stations.

One of the IPM successes in the region is the development of a sustainable, bio-intensive IPM package for onion that is widely practiced by the region's growers. Timely messages about farming can be relayed more quickly via radio than via other methods, like field days or trainings that take longer to organize. Because of this, IPM researchers and collaborators thought that All India Radio would be a good medium for technology transfer. This collaboration with AIR was the first of its kind for the program, and the Tuesday morning series became a ritual for many farmers.

At the end of the series, organizers held a final event at TNAU. More than 700 farmers from several districts of the Indian state of Tamil Nadu attended.

Throughout the day, exhibitions and demonstrations on IPM topics from the radio series were available for farmers. Participants received award certificates showing successful completion of the Farm School Radio program.

Ed Rajotte, principal investigator for the IPM Innovation Lab's South Asia Regional Program, was in the audience that day. "A farmer held up his radio and said, 'This is my university!'" Rajotte said.

Grafting spurs on business, reduces deforestation in Ecuador

In Tandapi, Ecuador, 40 miles northwest of Quito, the IPM Innovation Lab worked with local farmers to improve naranjilla production. Naranjilla (pronounced "nah-ren-hee-ya") is a small orange fruit, which is served juiced, sweetened, and iced.

While it has the potential to be cultivated and marketed widely, common naranjilla faces significant agricultural problems from pests and diseases.

In the subtropical, humid conditions of the Andean slopes, naranjilla farmers often move their cultivation sites after just one season because of fusarium wilt, a soilborne fungal disease. The disease, which affects a wide variety of plants, stays in the soil season after season, and there are no chemicals that can effectively control it. This planting pattern results in deforestation and erosion, easily spotted on the slopes where precisely trimmed patches of forest hover over bare land.

Program collaborators at INIAP—Ecuador's national institute for agricultural research—found that one wild solanaceous plant, *Solanum hirtum* (it's in the same genus as naranjilla), is resistant to *Fusarium* wilt as well as an infesting roundworm, the nematode *Meloidogyne incognita*. The same variety is more tolerant to drought, making it climate-smart.

Common naranjilla and its fruit receive a price premium of nearly 50% over other varieties. By combining the two varieties through grafting, farmers can grow a superplant with pest and disease resistance as well as high production and market value.

While grafted plants are more expensive than traditional plants, researchers have found that they could increase economic returns by 40–60% compared with non-grafted plants. The grafted plants also produce fruit for a longer period of time. And, cultivating the grafted plants means farmers aren't having to constantly clear the forests, ultimately reducing deforestation.

Farmers face additional pest and disease problems with naranjilla cultivation, but program researchers have come up with a group of IPM recommendations to help them. These include field sanitation, fruit borer control by using low-toxicity pesticides, and late blight control through organic fungicide application. These environmentally-friendly, human-friendly methods are a welcome solution for naranjilla farmers.

Grafting transforms life in Jessore, Bangladesh

In western Bangladesh, under the shade of a bamboo-framed thatch roof, two women sit and work with a razor blade and eggplant seedlings. With a deft movement of hand on plant, Shovarani Kar and Trishna Rani Biswas are able to graft a high-yielding variety of eggplant onto the rootstock of another variety that is resistant to a devastating soil-borne scourge: bacterial wilt.

Under the IPM Innovation Lab, these women have been trained in the grafting of eggplant and tomato—and are *paid* to do so—thus raising their income while improving the yield for farmers. Word has traveled that people in this village are now earning more because of improved agricultural practices, and villagers from surrounding towns and even distant villages now travel regularly to this community to learn how to achieve the same results.

Because people in Gaidghat are earning more, it has raised their social status. They used to be addressed using the more familiar form of address in Bengali, “tui,” which is used to speak to children or someone of lower status, but are now addressed with the term “apni,” reserved for someone of a higher status.

The women use the money they earn to purchase milk to improve the diet of their children and buy them clothing and school-related necessities such as books, notebooks and pens.

Grafting has not solved all of the farmers’ problems. But the program’s leader, Rezaul Karim, is optimistic. “Change happens slowly, but once it happens, it goes on and on.”

The grafting effort is part of a larger program under the IPM Innovation Lab, which has been working in Bangladesh since 1998. The eggplant grafting program was introduced in Jessore, known as the “vegetable basket” of the country, in 2003.

PRIVATE PARTNERSHIPS

In order to build capacity in developing countries, the IPM Innovation Lab engages in private sector development through technology transfer. This means that when the program has successfully identified a method to control a crop pest, the production and marketing of the technology is turned over to private enterprises. Transferring a technology to the private sector ensures crop protection for the long term.

Private partnership initiatives

Bangladesh

- Small nursery businesses have taken over tomato and eggplant grafting to sell to local farmers.
- The Ispahani company produces and markets parasitoids to control caterpillar pests and pheromones for vegetable pests.
- The Mennonite Central Committee, an NGO, provides farmers training on the production of *Trichoderma*, a beneficial fungus.

Ecuador

- PILVICSA, a private company, produces and markets grafted naranjilla seedlings that are resistant to *Fusarium* wilt.

India

- After a parasitic wasp was found to control the papaya mealybug, small companies took over its production, benefitting papain and silk-producing businesses and saving millions of dollars for the papaya industry.
- Tamil Nadu Agricultural University transferred NPV, a virus to control tomato and cabbage pests, to BioControl Research Laboratories in Bangalore.
- Several small companies produce and market beneficial fungi and bacteria to control soilborne diseases in vegetables.
- Over 20 different pheromones are locally produced and sold.

Indonesia

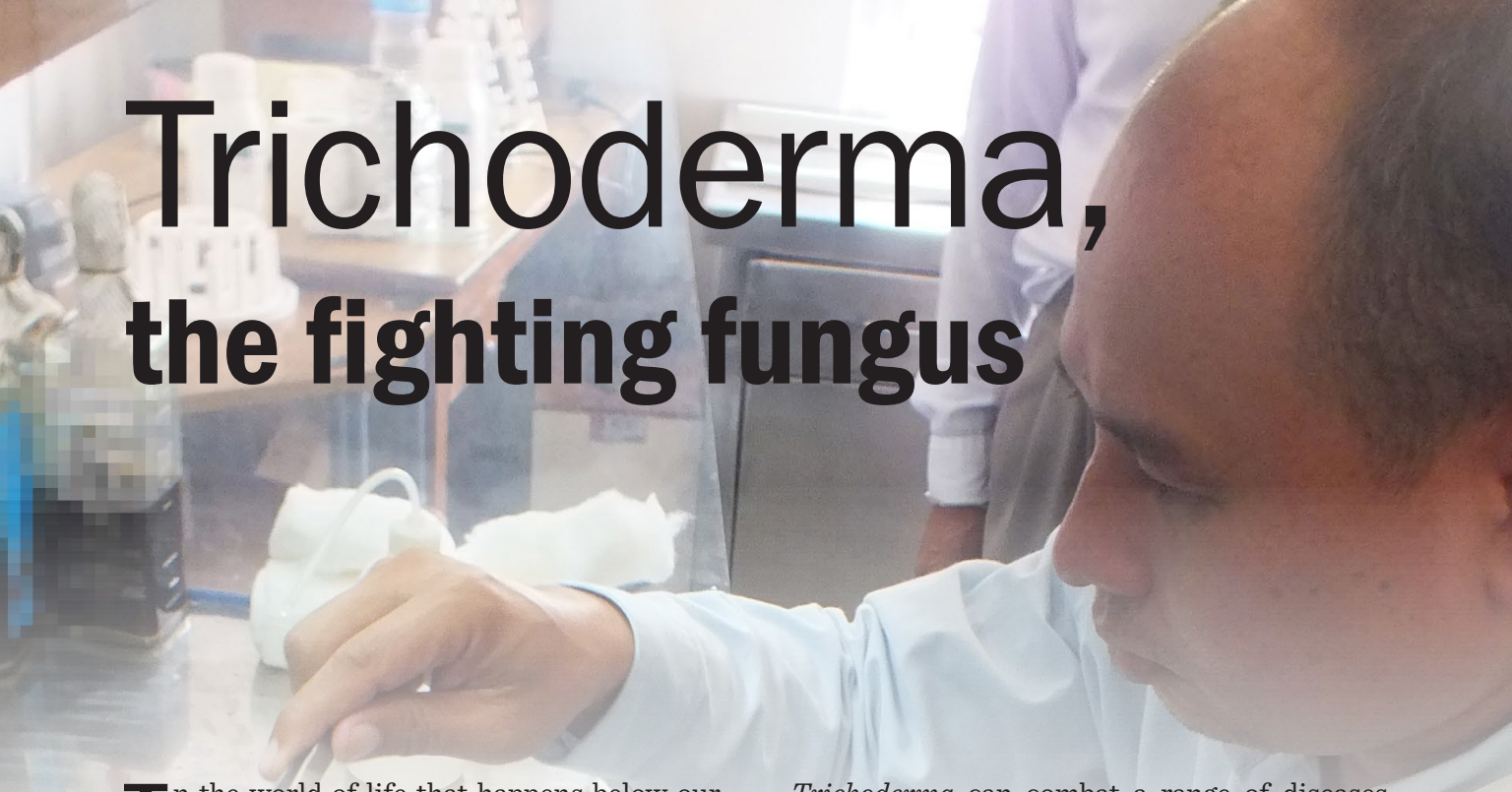
- *Trichoderma* is produced by Pak Ujang, a farmer in West Java, and packaged and marketed by a private company, PT Fumure.
- Lembaga Pertanan Sehat, a small business, produces and markets biopesticides and botanical insecticides to control vegetable pests.
- PT Agrotech Sinarindo, a small business firm, is now producing biopesticides and marketing them to farmers.

Nepal

- Small nurseries have taken over tomato and eggplant grafting, producing wilt-resistant plants for farmers to purchase.
- The private sector firm Agricare is commercially producing *Trichoderma* and *Beauveria*.

Philippines

- Vesicular Arbuscular Mycorrhiza, a beneficial fungus, has been transferred to farmers and small businesses to control soilborne diseases in vegetables.
- *Trichoderma* is currently being produced by communities and by a private firm.



Trichoderma, the fighting fungus

In the world of life that happens below our ability to see it, there lives a tiny hero. Scientists have found that a fungus called *Trichoderma* is especially good at eating "bad" fungi. And in developing countries, fungal diseases that attack and destroy crops are a major problem. This makes *Trichoderma* a welcome tool in the agriculturalist's toolbox.

Scientists with the IPM Innovation Lab are using *Trichoderma* to combat a range of fungal diseases that affect crops from India to Honduras.

In India, the commercial production of *Trichoderma* has been so successful that Tamil Nadu Agricultural University built a new plant pathology building with money collected from the sale of the fungus.

Scientists have found that they can treat seeds with *Trichoderma*, thereby preemptively protecting seedlings, in effect inoculating them. This protection can be effective for as long as 18 months after application. In addition to producing stronger roots, *Trichoderma* can also produce longer ones, making plants more resistant to drought. This can be especially valuable in areas where rainfall is not reliable.

Trichoderma can combat a range of diseases on vitally important crops. In India, it is used against fusarium wilt and pythium rot, which attack vegetable crops. In Indonesia, it is used against clubroot, which attacks broccoli. It's being tested on diseases of chili and tomato—horticultural crops that many farmers depend on. And in the Philippines, it is used to combat anthracnose bulb rot, damping off, and pink rot—diseases that decimated fields of onion before *Trichoderma* came to the rescue.

In Bangladesh and Indonesia, *Trichoderma* is mixed with compost and applied in the field to combat soilborne diseases. In India and the Philippines, seedlings are dipped in a fungus solution as a treatment for vegetable crops. And in Honduras, it is being tested on watermelon for the control of fusarium wilt.

Pak Ujang, a farmer in West Java, has made a successful on-farm business venture out of making *Trichoderma* to share with farmer groups in his area. He now produces enough of the fungus to supply a private company that packages and markets the product across Indonesia.

"*Trichoderma* is responsible for the profits I earn from my farm," he says proudly.

Plant diagnostics to the rescue

Peter Niwagaba picked up the pepper plant with the wilting leaves and turned it over in his hands. Were the drooping leaves indicative of bacterial wilt? Or of some other problem? He consulted with his team partners, and they made notations in a notebook.

Niwagaba and the 19 other workshop participants were attending a plant disease diagnostic workshop in Dakar, Senegal. The scientists had come from 11 countries from South Asia, and eastern and western Africa.

Knowing how to diagnose plant diseases is critical in designing an appropriate response. Damage that may look to the untutored eye like it's due to an insect might in fact be due to a virus, and vice versa.

Yet in many developing countries, skilled plant pathologists—those people who study plant diseases—are few and far between. In their absence, farmers make their best guess as to what's damaging their crops, and often apply pesticides that kill not only the bad bugs, but the good bugs as well. Not to mention that the pesticides may have other deleterious health affects on those applying the pesticides, and represent an extra expense.

"Farmers in developing countries often haven't had the chance to learn about appropriate methods of dealing with plant diseases," said Sally Miller. Miller is an IPM Innovation Lab project leader, professor of vegetable pathology, diagnostics, and international development, and a leader of the workshop. "What we have found in our research is that simple interventions can have a huge impact on a farmer's productivity."

In the plant diagnostic workshop exercise, plants showing disease of some kind were laid out on a long table. The group was divided into teams of 4-5 people. Each group reviewed each plant and wrote down what they thought were the host plant, the symptoms, and the disease in question. Teams then took turns standing before the larger group and presenting their findings for five of the plants. Members of the larger group either confirmed their diagnosis or explained why they disagreed. Finally, experts like Miller weighed in.

"What we have seen is that workshop attendees go back to their countries and share the information they've learned," said Muni Muniappan, director of the IPM Innovation Lab.

IPM Innovation Lab empowers women through gender workshop in Mali

Everything we do in life, whether we are aware of it or not, is gendered. Keeping this in mind in developing countries is especially important as access to resources, use of time, and ability to take certain actions are governed by gender considerations.

Muni Muniappan, director of the multimillion dollar IPM Innovation Lab, says that "it is now more important than ever to incorporate gender into this program."

To this end, Maria Elisa Christie, director of The Women and Gender in International Development Program at Virginia Tech, led a four-day gender workshop in June 2009 in Baguinéda, Mali.

The workshop, Gender, Participatory Research, and Technology Transfer, drew 30 researchers, extension agents, and representatives from institutions in West Africa that partner with the Integrated Pest Management Innovation Lab.

Although development organizations recognize that projects are most effective when they take women's needs into account, Christie notes that simply including women is not enough. "It's important to understand gender as relationships between men and women that affect development rather than simply focusing on involving more women."

Workshop attendees—both men and women—developed activity profiles, learning who (men or women or both) does what activity, when, and where. In one exercise, villagers drew a map of their village and its resources—a mosque, a soccer field, a maternity clinic, a well, and a cemetery.

"The group was surprised to learn that while women had access to most of the resources, women also had control over very few," says Christie. "For example, while women are the ones who do all the collecting and carrying of water, men control the wells."

Understanding resources and who controls them is critical to a successful development program, especially one as large as the IPM Innovation Lab.

Working together moving forward: Innovation Lab partnerships

A sustainable world means working together to create prosperity for all. – Jacqueline Novogratz

By partnering with other Innovation Labs, the IPM Innovation Lab has been able to dramatically expand its impact. These partnerships have helped control a serious pest of the commercially important peanut crop in Uganda and deal with a pest of pearl millet in West Africa.

Partnering with the Peanut and Mycotoxin Innovation Lab

Peanuts are a big deal in Uganda. Known as groundnuts, they provide extra income and play an important social role. Women serve them to guests as welcome food, and share the news of the day while sorting the legume—an important feature of daily life.

But in 1997, an unwelcome visitor made an appearance. *Aproarema modicella*, more commonly known as the groundnut leafminer, crossed into the east African country and began causing serious crop losses. Scientists from the IPM Innovation Lab, partnering with researchers from the Peanut and Mycotoxin Innovation Lab and others from Tamil Nadu Agricultural University in India and the National Semi-Arid Resources Research Institute in Uganda are looking to do several things: set up pheromone traps to monitor the pest, and identify the insect's natural enemies. One option that is being considered is to release *Trichogramma*—a tiny wasp that likes to parasitize insect eggs.

Partnering with the Sorghum and Millet Innovation Lab

Pearl millet is a crop that most of us are unfamiliar with in the United States. But the stalks of grass covered with tiny grains—similar in appearance to the cattail—were domesticated as a food crop in tropical West Africa as long as 4,000 years ago. Today, pearl millet is an important commercial crop in West African countries.

That's why the millet head miner is such a threat. When it attacks fields of pearl millet, farmers can see their crop suffer up to 80 percent damage. But scientists from both the IPM and Sorghum and Millet Innovation Labs are working together to change this. They are rearing, in great quantities, the parasite wasp *Hebrobracon hebetor*. This tiny wasp, when released in infected fields, lays its eggs inside the millet miner caterpillar, killing the pest. Farmers are again able to grow pearl millet.

And people can again eat this healthy grain with its hint of sweetness and nuttiness that is an essential part of their diet.

Building capacity in agriculture in the developing world: Why we need short and long-term training

Putting food on the table is a challenge for millions of people around the world every day. Surprisingly, according to experts, inadequate instruction in agricultural techniques as well as inadequate facilities are behind much of the deficit.

Even areas that have rich natural resources may be lacking in people who know about the latest diseases and how best to deal with them. They may not have labs that are necessary to identify what kind of pest is attacking a plant, or that are used to rear biocontrol agents such as parasite wasps or beetles that eat invasive plants.

By providing focused training that is targeted to a locale and that meets students where they're at, the IPM Innovation Lab is able to have a significant impact. Instructors learn to distinguish between a disease caused by a virus or an insect. They learn techniques such as how to use pheromone traps to monitor insect pests, how to best plant seeds in order to grow the most produce, or how to enhance soil by treating it with a beneficial fungus.

Short-term training—such things as farmer field schools and on-site demonstrations—educates farmers and extension agents, who then share this information with others.

Long-term training—undergraduate and graduate education—develops people who will be the future leaders of their country. These individuals will go on to become ministers of agriculture, executive directors of NGOs, and agricultural agents who will have major responsibilities for crop protection in their home country.

With this kind of training ("**human and institutional capacity building**," as it is referred to by development professionals), the IPM Innovation Lab sees huge positive impacts. In Ethiopia, the project assisted in establishing the first quarantine facility at the Ambo Plant Protection Center of the Ethiopian Institute of Agricultural Research. This means that scientists can now test the safety and effectiveness of biocontrol agents.

The IPM Innovation Lab doesn't limit itself to training foreign nationals. Instruction is also made available to young American scientists who are in fields that often lead to an international development career.

The IPM Innovation Lab is betting that strategic investment in the world's number one resource—its people—will pay big dividends. As a folk saying might have it, "A mind filled with agricultural knowledge means a stomach filled with food."

Supporting dreams

Invasive pests. Biocontrol agents. Smallholder farmers. All of these are things we think of when we consider integrated pest management in the developing world. But what about life-changing financial support that can help a person realize their career dreams? Not so much.

And yet, the IPM Innovation Lab provides just this kind of support for many young scientists around the world.

Take Sylvia Kuria and Michael Osei.

Kuria, a research scientist from Kenya, speaks passionately about the importance of growing healthy plants in her home country. “In Kenya, horticulture is the most valuable agricultural sub-sector,” she says. “It plays a major role in meeting people’s domestic [consumption] needs. It also employs four million people who produce crops for the export sector.”

Kuria is employed as a research scientist at the Kenya Agricultural and Livestock Research Organization, and she is also training at Makerere University in Uganda, where she is pursuing a master’s degree in plant pathology. Once she obtains her degree, Kuria hopes to return to Kenya, advancing to positions of increasing responsibility and helping to set policy for her country. The funding for her graduate degree comes from the IPM Innovation Lab.

Michael Osei works as a plant breeder at the Council for Scientific and Industrial Research: Crops Research Institute in Kumasi, Ghana. Farmers in Ghana, he says, face numerous pest problems. “Fruit flies are a serious problem—on mangoes, citrus, and melons. Aphids on cabbage are a problem. And, there is the tomato fruit borer.”

While Osei’s research on the discovery of new tomato virus strains has won him runner-up in the National Best Young Scientist award in Ghana, he does not rest on his laurels. He, along with Kuria and six other researchers from developing countries, attended a workshop on the production of biocontrol agents in Coimbatore, India provided by the IPM Innovation Lab.

Both Kuria and Osei understand that the road ahead in growing food for the world’s millions will not be easy. But training is part of the answer. And Osei might remind us of a Ghanaian proverb. “If things are getting easier, maybe you’re headed downhill.”


Local Name: Cabbage
Scientific Name: Brassica oleracea
Scientific Name: Basella rubra
Local Name: Alugbati
Variety: TQT 1578