

## Asian Vegetable and Mango IPM Trip Report

**Countries Visited:** Cambodia, Bangladesh, Nepal

**Dates of Travel:** January 21- February 9, 2016

**Travelers Names and Affiliations:** Megan O'Rourke, R. Muniappan, E. Heinrichs, Maria Elisa Christie, George Norton (Virginia Tech), Sally Miller (Ohio State), Cristina Rosa, Ed Rajotte (Penn State), Sulav Paudel (iDE, Nepal)

**Purpose of Trip:** To plan details of vegetable and mango IPM program for the next year for the target countries

**Sites Visited:** Dhaka and Gazipur, Bangladesh; Phenom Penh and Siem Reap, Cambodia; Kathmandu and Lalitpur, Nepal

### **Description of Activities/Observations:**

*January 21- 23:* U.S. scientists left United States (and Paudel left Nepal)

*January 23-24:* Scientists arrived in Phenom Penh, Frangipani Villa hotel

*January 25:* Phenom Penh – U.S team met with Claudius Bredehoft of GIZ and Buyung Hadi of IRRI. Claudius is working a project until 2017 that works on biocontrol regulations and other issues to help commercialize biocontrol products in Cambodia. Guidelines approved in 2014 for ASEAN countries. Claudius has worked with HARVEST project to commercialize products. Trichoderma is being brought in from India and Thailand. He is interested in possible Trichoderma workshop in Cambodia together with the IPM IL and the Government Department of Agriculture. Buyung will have new IPM IL project for rice IPM in Cambodia. He is also working with GIZ.

U.S. team and S. Paudel then went to iDE Nepal and met with Mike Roberts, iDE Director, Bruce Todd who heads up iDE work in Siem Reap under an organization called the Cambodian Agricultural Development Facility (CADF) and manages the CODES project (a horticultural value chain project funded by New Zealand), Seng Kimhian who is a PhD agronomist who will coordinate IPM IL work in Cambodia, and others at iDE. Mike described work on iDE and then Bruce described CODES, which focuses on commercial horticulture production in the Northwest provinces (550 square meters to one hectare is the average area of production per farm). They use a tool-kit of inputs. They do demonstrations without matching controls to gauge pest pressure. Miriam Pastor, Design and Research Strategist, inCOMPASS/Human-Centered Innovation Lab at iDE described her project and a participatory exercise they have completed with a small set of farmers. The exercise gave a general idea of the motivations behind farmers' decisions regarding the use of pesticides on of protective equipment.

Part of the team then met with Seng Lee, Agriculture Officer and Deputy Director for Food Security for USAID Cambodia and with Tonh Mok, M&IE for USAID Cambodia. Seng stressed the importance of coordinating with the Mission on any IPM IL activity, especially because the Mission needs to coordinate across many IL projects and does not want to be surprised when programs or even meetings are being planned with Cambodian Government institutions. She would like to know about scheduled activities well in advance. She expressed interest in Sandwich-type graduate programs for Cambodian scientists.

Part of team met with Rithykun Khan, Director General of GDA, Ngin Chhay, Director of Rice and of IPM for GDA, and Kean Sophia of GDA who works with Trichoderma. They indicated that there are IPM coordinators in the provinces and would like GDA to be formally involved with the IPM IL vegetable project. They discussed the need for a policy framework for bio-pesticides. GDA would be sending 3 scientists, including Ngin Chhay to the planning meeting the next day for the IPM IL program.

The other part of the team visited a provincial research station east of Phnom Penh. This station mainly evaluated crop varieties for local farmers and arranged for improved seed distribution. The station was understaffed because several of the station scientists were drawn away to work on projects elsewhere.

January 26: Morning -- Planning meeting for IPM IL vegetable IPM program in Cambodia (3 participants from GDA, 2 from the Royal University of Agriculture, 2 from ATSA, 8 U.S. scientists, and 3 from iDE). After introductions, George Norton gave a summary presentation on the Asian Vegetable and Mango IPM program and Ngin Chhay gave a presentation on the existing national IPM program in Cambodia. Maria Elisa Dr. Christie described the gender dimension of the project. Most of the morning was spent in an exercise (led by Ed Rajotte) to prioritize vegetable crops and pests in Cambodia with information provided by GDA, RUA, and ATSA. Results: (1) Most important crops: Crucifers – cauliflower, cabbage, Chinese cabbage, bok choy; Solanaceae – tomato (export, restaurant), chili; Legumes – yard long bean, French bean; Cucurbits – cucumber, bitter melon, melons; Allium – spring onions, bulb onions, shallots, chives; Lettuce and other non-crucifer greens (2) Markets - Export market for Cambodian vegetables not significant at present; Import substitutions very important; iDE focusing on off-season production (peak (dry) season is November - May); production declines later in dry season due to water shortage) (3) Pests: (a) Yard long bean (wet and dry season) -- Aphids (*Aphis craccivora*), Pod borer (*Maruca*), Bacterial wilt, Fusarium wilt, Damping off, Potyvirus, (b) Cucumber (wet and dry season) -- Fruit fly (*Bactrocera cucurbitae*), Downy mildew, Powdery mildew, Damping-off, Angular leaf spot, Pumpkin beetle (*Aulocophora*), CMV – aphid transmitted (*Aphis gossypii*), (c) Crucifers (wet and dry season) – priorities are Cabbage, Chinese kale, and Cauliflower and pests are Spodoptera, Diamond back moth DBM, Flea beetle, soft rot, Damping off/root rots, Black rot (*Xanthomonas campestris* pv. *campestris*), Clubroot (*Plasmodiophora brassicae*), Alternaria leaf spot (*Alternaria brassicae*, *A. brassicicola*), Webworm (*Hellula*), (d) Tomato (peak in dry season) – Pests are Viruses, Bacterial wilt, need rootstock evaluation (disease resistance, vigor, compatibility with scions needed), Late blight, Fusarium wilt, and *Helicoverpa* (fruit borer). Need to monitor invasive species *Tuta absoluta*. (4) Potential Collaborators in Siam Reap are PDA – Provincial Dept of Agriculture, iDE, Harvest, smaller NGOs, Women Farmers organizations, no university in SR but can work with Battambang University in nearby province. BU has a research farm that can be used for experiments. Also can work with Co-ops and private sector (FFF, Asia Irrigation, UCA). Potential Collaborators in Battambang are PDA, Battambang University. Also need to collaborate with UC Davis – Hort IL peri-urban project on leafy salad greens – Phnom Penh area; Royal University of Agriculture Center of Excellence (KSU Sustainable Intensification IL). (5) For program Implementation, can work through existing programs/structures for Demo/training plots, Research plots, Tech transfer. Want RUA student involvement in research and to work through GDA which has Farmer cooperators – on farm adaptive trials, National research stations, and Provincial research stations. Students from RUA can do research with GDA. GDA does not support students financially – grant funds needed. GDA experts lecture at RUA. Can also work with Eco-agriculture supported by SIDA (Sweden) – to 2018, IFAD – ASPIRE (new), and FAO Pest risk reduction program. There is also work supported by the Asian Development Bank – TSTD, Swiss Development Bank, and GIZ Veg Project in BMC. (6) For short – term Training, priorities are (a) biological control – also link to private sector and include botanicals,

focus on both broad concept – what is available and how it works and specifics – production and (b) Disease diagnosis and management – help needed on scope, audience. (7) There will be a Baseline survey with about 300 farmers.

IPM packages were listed for several major vegetables in Cambodia (Crucifers, cucumber, tomato, yard long bean). These packages are listed in the appendix to this report. IPM packages need to be locally evaluated in an adaptive research program.

During the meeting, Short Heinrichs visited the Royal University of Agriculture. He met with Vice Rector Men Sarom and Plant Protection faculty Ms Ong Socheath, Khem Taingleang, Dr. Lyda Hok and Kim Chanjout (Nagoya Satellite Campus) and visited the teaching and laboratory facilities. RUA, established in 1964 is the premier and largest agricultural university in Cambodia. The Nagoya University Satellite Campus project at RUA in training faculty provides the opportunity of sandwich training of IPM IL supported scientists for MSc and PhD degrees in Plant Protection disciplines. Laboratory and teaching facilities at RUA are adequate for effective training. Short had discussion on the RUA rice research program in relation to their future involvement in the IPM IL Rice IPM project led by Buyung Hadi, IRRI.

Afternoon – Half of us visited RUA and half visited field research plots. At RUA, we met with the Dean of the Graduate School, Thavrak Huon and Vice Director of the graduate school, San Sokunthea, and then toured the lab of entomologist Khun Kimkhuy. We were given a history of the university and a description of its organization. There are 10 departments and 8 centers. A student costs about \$6000 per year, including school fee, stipend and research fee. RUA has 162 total faculty members, 62% with MS degrees and 9% with PhDs. There are only 2 female PhDs. 5500 students overall. Has 192 MSc students and 15 PhD students (research only for PhD. Most students also have jobs. Therefore do not want sandwich programs that involve more than 1-2 weeks away. Faculty members make \$100 per month and many work other jobs. . Half of us visited the GDA vegetable research station sponsored by FAO and funded by ADB. The station serves as distribution source of seeds for poor farmers, collects seeds from farmers and provides storage. Many NGOs buy seeds here. Cucurbitaceae, tomato and bean seeds are the majority of the seeds propagated at the station. The research activities performed at the station are centered on seed cultivars and conservation, and they have started recently a seed program for improvement. Seeds are evaluated by comparative trials twice/year, for performance but also for disease and insect resistance. Data of survey are sent to GDA. Pheromones used for insect control are imported from Taiwan. The station has a total of 7 staff members, with crews of workers hired as needed. It was not clear if students were involved in any of the activities for this station. Staff is paid at a very low rate, so it is difficult to keep good employees.

Muni, George, and Mike met with Sarah Kozyn and Ben Freidman of Abt Associates for dinner.

*January 27:* The group flew to Siem Reap and met in the morning with the Plant and Food Research group at the CADF office of iDE (where the CODES project is located). We met with Graham Walke and Khong Sophoan who work with the Codes project, which focuses on commercial development and strengthening of horticulture in Siem Reap, Banteay Meanchey, and Otdar Meanchey provinces. Codes focuses on traditional vegetable crops such as cucumber and long beans as well as high value vegetable crops. They link growers and transport to markets. Graham focuses on the production side: rotations, high value melons, facilitating micro-finance, drip irrigation. Also focus on health and safety of agrochemicals: protective gear, pesticide safety. He focuses on insect pests and helping farmers to know insect pests and diseases. Has photos of all pests and diseases for 25 crops and their natural enemies. They do uncontrolled demonstrations to train farmers (one demonstration farm of 1000 sq meters in each community) and address high value promotional market

development for products such as cantaloupe. Has concern over lack of high quality (virus-free) seeds and their availability. Also, shortage of water in the dry season is a major problem.

In the afternoon we visited a HARVEST project site and met with Dennis Lesnick and Edwin Dekorte of Fintrac. They have assisted 4200 farmers with training, 83% of which have stayed with the practices. Fintrac has a staff of 300 on the project. Another 4-5 thousand farmers have copied their results. They have extended to farmers: drip irrigation, mulching, trap crops, pheromone traps (for gourds), and trellises. The investment of about \$1000 pays off in 2 harvests. There is 8 months of cropping per year. They focus on leafy vegetables (in wet season), gourds, eggplant, yard long bean, waxy corn, and cucumbers. 70% of vegetables consumed in Cambodia come from Vietnam. Downy mildew is a problem in cucumber. There are about 17,000 home gardens and 8000 commercial farms growing vegetables. 55% of clients are seasonal as there is competition with off-farm work. Farmers are organized into producer groups, which maintains trust with buyers. There are problems with bean rust and downy mildew. They use manzate and timing is crucial. They use a corn barrier for black aphids on long beans. Their IPM program is basically: biological controls, resistant varieties, plants trained to trellis, healthy seedlings, drip irrigation, live barriers to control aphids for virus control, spacing, and traps for monitoring. They use some netting but heat is a problem so does not work well. Netting does work on crucifers such as Chinese cabbage. Crucifers are only at the start of the dry season. Markets are mostly informal. M&E system data are available with production data for five crops and net returns. Works with university interns (MS and BS theses). Suggests workshop for Trichoderma in Battambang. There are 505 input suppliers. Worked with 47 extension agents and with large distributors. They teach record keeping.

January 28: The group visited the CODES project area and demonstration farms. They work with cucumber, long beans, eggplant, waxy corn, bitter melon, hot chiles, leafy vegetables all year long. They need help with tomatoes and cabbage. The farmers do not rotate rice with vegetables. Most farms now have hand tractors. They use plastic mulch, drip irrigation, and fertigation. Leafhopper a problem on eggplant if next to rice. We spoke to a melon producer who rotates eggplant with melons. There is a melon association with 75 members (going to 200). They produced 36 tons last month and average 25 tons/mo. For crops that need work on pest problems, Graham would prioritize tomatoes and brassicas in the dry season and bitter melon, melons, peppers, and leafy brassicas in the wet season.

At lunch, part of the group met with the Rector of Battambang University, Mr. Sip Pagrasoley. Their program began in 2008 with 5 faculty. They have land with research station 18 kilometers from the university. They have small amount of Trichoderma production and an entomology lab. They collaborate with the HARVEST project. He is interested in having the university collaborate with the IPM IL but he personally will be leaving the university in two months. IPM experiments and evaluations could serve as undergraduate thesis topics for students there.

The group visited the PDA station in Siem Reap and its director Hay Veasna. The station has 17 hectares with 8 of rice but few vegetables. There are 3 workers and they are involved in rice seed production for farmers. The station was adjacent to a horticulture facility sponsored by another donor.

In the afternoon, Maria Elisa visited the plots of women vegetable farmers in Thnat Village in Puok Commune in Puok District, Siem Reap Province to meet with the "women's self-help/savings group." The official name is the Khum Khnart Rong Rouerng Agriculture Cooperative and it consists of 45 women and 10 men. Rechaney Sel, a technician with the Hort IL project, helped Maria Elisa interview two farmers. The coop collects, stores, and sells vegetables. They have improved post-harvest facilities and are organized to sell at a premium. AVRDC had installed an evaporation cooling system

that allows farmers to store and sell at a higher price. The cooperative is working with the Conservation Agriculture and Drip Irrigation (CADi) Project. The farmers had individual plots of a maximum of 200 square meters (average 150). They rotate with three cycles: bitter melon, Chinese kale, and long bean. They spray pesticides for aphids/ladybugs and caterpillars among others. They have had training on “good bugs and bad bugs” by a Thai organization. The cooperative members also grow tomatoes and eggplant. They consider tomato diseases as their most important pest problem.

The rest of the group met at CADF for planning the research program. We planned the wet season (June to Oct) and discussed the following dry season (Nov to May). Table 1 below summarizes part of that effort:

Table 1.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Peak Veg		Too hot			Wet					Peak Veg	
Crops	Chinese kale-FFT					Chinese kale – FFT IPM package evaluation Hot water treat seeds Trichoderma seed/seedling/soil trt Nursery nets Pheromone traps (DBM, SPodoptera) Yellow traps Microbials Bt Scout for larvae; Bt at threshold Roguing for virus Mulching – straw mulch					Chinese kale	
						Cucumber – FFT IPM package evaluation Trichoderma seed/seedling/soil trt Nursery nets Pheromone traps – Fruit fly bait + Cuelure for Spodoptera Yellow traps Scout for pumpkin beetle; chem pesticide at threshold; scout for downy mildew – apply fungicides as soon as DM appears Staking Roguing for virus Mulching – straw mulch						
						Disease and virus survey (July – OSU) – Anna T, KH Check with Naidu on prev surveys Graham Walker doing pest survey						Disease (Anna T) and virus (Sulav) survey
						Tomato – component research on-station Ralstonia rootstock evaluation – RUA, BU (SAM, Kim Hian) Wet season package development – farmers plant tomatoes and pests/diseases observed– evaluate varieties, pests, diseases in SR (KH)						
Workshops				Trichoderma (Muni)		Potential 1-2 day disease diagnostics workshop		Potential regional pheromone workshop		Potential fruit fly workshop		

Set up of Farmer Trials

CODES	B u f f e r	IPM IL	B u f f e r
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Control

CODES interventions (as farmer practice) compared to IPM IL components or packages and Control (control may be smaller than test plots)

Minimum five farmers per trial; randomize on farms; each farm is a rep

Locations

Siem Reap

Battambang – student replicated plots

Phnom Penh – RUA – student replicated plots

The PDA station in Siem Reap is not capable of managing experiments, but is important to keep GDA involved. Therefore, GDA IPM coordinator Ngin Chhay will be asked to be part of a two person in advisory council to the project role (along with someone from RUA). GDA personnel will also participate in trainings.

Not clear if there is a role for ATSA. They are accustomed to technology transfer rather than research and they focus on different provinces. It would be better to have replicated trials done by students at Battambang and RUA.

The budget is quite constraining and so is Kimhian's time.

Dry Season Prioritization for crops will be:

1. Head cabbage
2. Tomato
3. Cucumber
4. Long bean
5. Chinese kale
6. Chili peppers
7. Sweet pepper
8. Cauliflower
9. Bitter gourd
10. Eggplant

Graham Walke stressed the importance of working on spodoptera and fruit flies (Brassicas, bitter gourd, and melons) and on mildews. He has had good success with fruit fly baits, either commercially obtained, or homemade using brewery waste (see appendix)

George, Megan, and Kimhian discussed the baseline survey and its budget. \$5000 is available from George's Virginia Tech budget. It needs to be done beginning in mid April and will be done with students as enumerators. It will be done in Siem Reap and Battambang. George will draft questionnaire and protocol.

The group had dinner with Stuart Brown who works on a project for scaling home gardens in Cambodia. We will keep him in the loop on our IPM packages.

*January 29:* Concluding meeting at iDE-CADF and then Muniappan, O'Rourke, Norton, Heinrichs, Miller, Rajotte, Rosa, and Christie flew to Bangladesh. Arriving at 8:30 pm.

*January 30:* Dhaka – The team met with Dr. Mozammel Hoq of the University of Dhaka. He has several strains of Bt and other biopesticides. There has been some large farm testing by Kazizi for tea but he would like to test and scale up for vegetables. He can offer strains to Entomology department of BARI. He has worked with USDA biotech program. He can give 1-2 strains to be tested by BARI scientists who can have an agreement with his lab. He can assign his MS student to work at BARI. He needs to link Bt strains to specific insect pests.

The team met with Yousuf Mian, IPM coordinator for the IPM IL in Bangladesh. We reviewed the set of draft proposals prepared by BARI scientists to be prepared for the planning meeting the next day.

Norton met with PhD student Sadique Rahman to discuss his dissertation. He will come to Virginia Tech on May to August.

*January 31:* The group travelled to BARI in Gazipur for a planning meeting at the Horticultural Research Center. Md. Shoeb Hassan, Director of Support Services for BARI chaired the inaugural session in which Yousuf Mian gave a welcoming address and remarks were given by Dr. Rezaul Karim, for IPM IL Director for the Bangladesh site, Dr. Norton, Dr. Muniappan, and Md. Hassan. The meeting was attended by about 20 BARI scientists (Total of 28 attendees, including 9 women). MCC was also represented. Each of the scientists with proposals presented them to the group. There were proposals to test IPM components or packages for: 1) Country bean (*sclerotiorum*) with component technologies to be tested and virus and pod borer are other key pests; 2) Coco dust in trays, 3) Mango, which has problems with hoppers, fruit flies, and Antracnose. It receives 25-35 sprays per season. Smudging and bag off clusters are possible IPM practices. 4) Eggplant thrips – This proposal was criticized as a demonstration and not research, 5) Eggplant package that includes hybrids to control bacterial wilt and will be compared against grafting. Bt eggplant will also be included as a component, 6) bittergourd, and 7) Summer tomatoes – comment that the proposal should drop the demonstration and add a new rootstock. There was a discussion of need to control mites in *capiscum*, which can become a year round crop. Each proposal received some comments and the BARI scientists whose proposals will still be considered were asked to revise them and resubmit them through Yousuf for the U.S. scientists to comment on. Part of our group visited the fields at the BARI and looked at diseases and insects.

Planning for the fall season was begun with discussion that Eggplant and tomato take priority. The latter needs a plan to address the upcoming *Tuta absoluta* (leaf miner) problem. A large eggplant experiment is needed that includes Bt eggplant. Melons and gourds have a red pumpkin beetle problem. *Capiscum* was also discussed.

Norton met with Dr. Rashid of the Socioeconomics unit about his prior evaluation of Bt eggplant and about a new impact assessment that will begin next November. He would also like to do one in the summer season with 400-500 farmers. Norton will get back to him after discussions with Cornell about it.

Maria Elisa met with Dr. Nahar and Mr. Jahangir (MCC) to discuss gender research with *Trichoderma* under the previous IPM IL phase and to plan publishing of results.

*February 1:* Muniappan, Norton, Heinrichs, and Mian met with at USAID with Mark Tegenfeldt, Matt Curtis, and M. Shibley to discuss the new IPM IL Asian vegetable and mango IPM program. This issue of Bt eggplant came up and its evaluation. Mark said that discussions have been held with IFPRI over such an evaluation and suggested that the IPM IL, Cornell, and IFPRI work together. Norton said that we would all discuss that possibility.

The whole group then met with Mike Fields and Bani Amin of DAI to discuss cooperation between the USAID-supported Feed the Future Agricultural Value project and the IPM IL Asia Vegetable and Mango IPM program. The ag value chain project has field offices in Jessor, Barisal and Faripur. Crops that overlap between our two projects are mango (which was included in the IPM IL because of the ag value chain project), tomato, and summer vegetables such as eggplant, bitter gourd, and cucurbits. DAI takes a farm-to-market approach that focuses on the marketing system (social, political, and economic analysis and incentives along the marketing chain). They are looking at market structures (which are currently very atomized) and rules such as grades and standards. They go from research to commercialization and look at distributional channels. Mrs. Serajul Islam is their technology commercialization leader. Hey work with Ispahani just as we do.

In the afternoon, half the group went visit the program of M. Hoq at the University of Dhaka and the other half met with Ibrahim Khalil of Ispahani. M. Hoq provided tour of his labs and introduced his post docs, colleagues and students. University of Dhaka has high quality projects involving production of biopesticides including multiple Bt strains. They have fermentation equipment that can scale up production. This facility should be brought into the IPM IL in Bangladesh. M. Hoq has a very dynamic and modern lab, with about 10 students working on different projects, including the characterization of ca. 150 Bt strains. Faculty members at his department have been mainly trained overseas, and are extremely competent and capable of doing research.

Ispahani has experienced 72% sales growth of pheromone traps, trichoderma, and biopesticide products. There are 100,000 hectares under their traps (gourds, eggplant, chickpea). One million lures sold last year. 62% growth/year over the last five years. They sold 50 tons of Trichoderma (suspension, solid, powder, mixed with blackgram bran) last year. They train farmers to mix it with compost. They sell bio-neem, SNPV, and Bt. They have 288 distributors who each sell to 8-10 retailers. They trichogramma and Bracon, but mostly to the government for eggplant fruit and shoot borer, mango fruit fly. They sell Beauveria for use against mango hopper (70% control). He has not worked with DAI.

Norton met with GP Das, who leads in the Bangladesh the Cornell biotechnology project that used to be called ABSPII, to discuss the impact survey of Btw eggplant. He feels that conducting a joint survey with IFPRI would be complicated. Four varieties of Bt eggplant have been developed. We discussed the IPM package for eggplant and he feels that Thrips, red mites and white fly, especially the latter two are major problems in addition to FSB that the Bt eggplant addresses.

*February 2:* Muniappan, Heinrichs, O'Rourke, Rajotte, Rosa, Miller, Christie, and Norton traveled from Bangladesh to Nepal.

*February 3:* The group met in the morning at iDE-Nepal to discuss the new IPM IL Vegetable and mango IPM program, which iDE will coordinate in Nepal. iDE-Nepal Director, Luke Colavito first reviewed difficulties related to the April and May earthquakes in 2015. The IPM IL program, with USAID's permission, provided emergency relief to 1000 families in project areas outside of Kathmandu.

IPM activities continued this past year, linking with KISAN and USAID iDE projects. They are reaching 17-18,000 households with Trichoderma, traps, and netting through KISAN and 30,000 households through other iDE projects. Phil Brotan is the new COP of KISAN. In addition to projects with other donors, iDE is working with the USAID Food for Peace program handling the agricultural part of the PAHAL project – smallholder crop production; 14 districts of mid- and far-west; 11 in FtF zones; no Terai districts. Unfortunately, USAID Washington has not approved the work plan yet even though it has been a year. iDE is also working with the USAID India Mission Partnerships Program (\$2Million;



\$200K targeted to Bhutan – 1,000 households) to link Indian agro-technologies to Nepal and Bhutan, hoping to reach 50,000 households. They are linking to a BRCL subsidiary (Everest) in Nepal and with Harvell Azud on micro-irrigation systems. There is also a manufacturer in Nepal selling about 6,000 systems per year for entry-level hill farmers.

KISAN has done a PERSUAP and Luke will send it to Muni.

iDE focusing on climate change work through LAPAs (Local Adaptation Plan of Adaptation) that operate through village level committees. They identify insect pests and diseases as a major problem and is an opportunity to involve IPM IL, USAID, DIFID, local governments. There has been a recent outbreak of coffee rust in Nepal for first time. The monsoon is generally coming later, is more erratic and a problem for the rice crop. There is a need for irrigation or shorter season varieties. Predictions – higher concentrations of rainfall in monsoon; more intense rainfalls; Less rain overall; Increased problems with hail in some regions. Good quality plastic protects from rainstorms. There is interest by government in use of weather forecasting data for crop production. Most farmers do not pay attention to forecasts. IPM IL wants to link government weather forecast data to collection centers. This would work better in terai than in the hills where there is a lot of variability. There is a small USAID effort – weather data being connected from Accu-Weather being sent to farmers via SMS messaging – but not very accurate here. New coordinator – Lalit Shaa

We met with representatives from the Plant Protection Directorate: Mr Dinesh Babu Tiwari, Natl IPM Program and with FAO rep Dr. Naworaj Acharya, IPM/GAP expert FAO Nepal. They gave ppt presentations. The PPD implements a pest management program in Nepal and addresses regulatory issues. It has an IPM strategy and promotes the private sector. It has five regional plant protection labs and is establishing a bio-pesticides resource center. There are 6 registered bio-pesticides. They have a pesticide residue lab. Their major activities are to:

1. Review and propose improvements in national pesticide legislation, regulations, policies, plans and SoP
2. Capacitate government staff in pesticide registration, monitoring and management
3. Strengthen/extend RBPR (Rapid Pesticide Residue) laboratories to major cities
4. Capacity building/increase compliance of private sectors to pesticide regulations, legislation and CoP
5. Establish/strengthen Community Resource Center for production of biopesticides
6. Increase compliance of crop producer/farmers and coops to safe handling of pesticides
7. Enhance awareness of consumers to increase their capacity to choose safer foodstuffs – mass media campaign, documentary on TV, etc.

Their major problems:

1. Unavailability of effective/reliable alternative tools
2. Insufficient knowledge/skills to practice IPM
3. Lack of market and premium price
4. Product identification issues
5. Small land holding and subsistence farming – problems in diversified

The FAO pest management program can help IPM IL with revisions needed to national IPM policies.

After lunch, we met with the IPM IL Climate Change project of the IPM IL which is led by City University of New York. PI Nir Krakauer noted that the basic research questions focus on biological/agricultural groups: pests, pollinators, predators. Main project procedure is to assign AFU students to do thesis research on these topics. They look at raptors and pollinators and are looking at impact of production practices on biodiversity. They will do altitude transect at 10 sites and

ecological niche modeling. Ed suggested that ecosystem services piece could be basis for collaboration. What are the pest species that overlap two projects? Muni suggested that Bemisia (polyphagous), P. raphae and banana leaf roller might be good targets. Muni suggested looking at remote sensing data/satellite pictures for vegetation. The Climate change project is collaborating with TU/Central Department of Botany; Pests and diseases will be handled by Agriculture and Forestry University (AFU); They will have workshops on scientific writing – perhaps our students participate. We will communicate with them about our workshops.

February 4: Muni, Heinrichs and Norton met with Navin Hada from USAID Nepal to discuss the new program. The whole group then met with private sector reps: (1) Kalpa Brikssya (10 years in business) – Nelson Shrestha. Has bio-pesticides lab: Trichoderma (2) N-Agro sells improved vegetable seeds; 10 years in operation. Now working on disease resistance, partnering with Enza Zaaden --six new varieties with CMV, and other virus resistance. Giving farmers training on IPM implementation with disease resistant seeds and high tunnels/bamboo structures. Buying produce from farmers; will collect, grade, package and sell -- Periurban focus around Kathmandu. (3) Rajish Shrestha -- Import biocontrols from India – Coimbatore. Want to produce Trichoderma here eventually but need high quality product. Currently lobbying govt of Nepal. Introducing high tech greenhouses with drip irrigation, fertigation, but lack knowledge and don't have water-soluble fertilizer. Govt doesn't allow import of water-soluble fertilizer.

We held large stakeholder meeting with representatives from CEAPRED, NARC, PPD, DOA, FAO, iDE. Luke Colavito summarized the iDE program and approach that involves use of community business facilitators to train and make IPM inputs available to farmers. Agriculture highly subsistence oriented still with private sector mainly in district capitals. Most private companies are small, lack technical capacity, and function as distributors of imported inputs. The iDE strategy is a smallholder commercial approach with 200 pockets (collection centers) with 150K households. This approach is being mainstreamed in USAID, with support from Govt of Nepal. IPM IL Scaling Strategies are to link IPM technologies to projects/programs developing: Rural collection center networks; Last mile supply chain with training packages for CBFs, CC, stakeholders and demos targeted to CC to include in crop calendars, link CCs and Community Business Facilitators (CBFs) to Dept of Ag/PPD capacity/Plant Doctors, CBFs sell IPM Products to farmers, private sector involvement. Showed video of earthquake recovery -- Provided plastic for 1000 HH to build temporary shelters, some families moved into their high tunnels, Agriculture Rehabilitation Project with seeds (fast growing veg crops) and IPM inputs, Agricare discounted Trichoderma, developed 8 nurseries for seedling production, and developed voucher system thru local supply chain.

Sulav Paudel gave an update on the previous IPM IL program: Nursery management – Cocopeat and plastic trays increased germination significantly; Trichoderma-enriched compost; Higher yield of cauliflower, reduced root rot; remaining virus problems and need more help in identifying viruses; Virus diagnostic training with NARC, WSU, VT an another virus training to come; concern over Tuta absoluta – South American Leaf Miner; Tuta workshop last year; Will soon be in Nepal and coordinated effort needed; Vegetable grafting needed for root knot nematode and bacterial wilt; IPM learning/demo center, 2 each in Bahnke and Surkhet; have IPM packages and components; tomato IPM Package reduced sprays from 8.7 to 2.4; working with Hort IL on Conservation Ag.

George Norton summarized the objectives and approach of the Asian Vegetable and mango IPM program. We then broke into two discussion groups: one to develop the crop and pest priorities for the technical plan and the other to discuss collaboration across all the partners. Results of prioritization exercise:

- Tomato
  - o Whiteflies
  - o Solanum sisymbriifolium rootstock failure – new rootstocks needed
  - o Peanut bud necrosis virus
  - o Thrips
  - o Lyriomyza leafminer
  - o Spider mites
  - o Helicoverpa
  - o Fulvia leaf mold in polyhouse conditions in monsoon season
  - o Root knot nematodes
  - o Septoria blight
  - o Pith necrosis
  - o Alternaria stem canker
  - o Late blight
  - o Damping off
- Crucifers - Cauliflower and Cabbage
  - o Clubroot
  - o DBM in summer
  - o Spodoptera
  - o White grub
  - o Wirestem (Rhizoctonia)
  - o Soft rot
  - o Damping off
  - o Downy mildew
  - o Alternaria leaf spot
  - o Black rot
  - o Cabbage butterfly (Pieris)
- Cucurbits - Cucumber and Bitter Gourd
  - o Viruses (CMV and Potyvirus)
  - o Fruit fly
  - o Gummy stem blight (Didymella) – bitter gourd
  - o Downy mildew
  - o Powdery mildew
  - o Root knot nematode
  - o Epilachna
- Eggplant
  - o Leucinodes
  - o Spider mites
  - o Sclerotinia white mold
  - o Bacterial wilt
  - o Little leaf phytoplasma/leafhopper vector
  - o Thrips
  - o Phomopsis blight
  - o Cercospora leaf spot – terrain
  - o Epilachna beetle

#### New crops for IPM IL

- Onion (dry bulb) – third most grown vegetable in Nepal
  - o Thrips
  - o Tip blight (burn): We need to check what this is actually!

- o Purple blotch
- o Downy mildew
- o Virus
- o Garlic rust – (minor problem in onion)

Monitoring Onion insects and pests (Scouting regularly)/ This season

- Crop husbandry practices needs to be taken note of.
- Asking RAM Khadka/Vijaya to look into the virus and disease on Harvesting bulb at the right time (harvesting)
- Okra – major vegetable in terrai
  - o Leafhoppers
  - o OFSB
  - o Yellow mosaic
  - o Whiteflies
  - o Mites
  - o Thrips
  - o Cercospora leaf spot
- Capsicum/chili
  - o Phytophthora blight
  - ☐ Compost + Trichoderma could be one of the component of the package in raised bed
  - ☐ If we want to do, Dr. Miller can send us a protocol (in research station only)
  - o Thrips
  - o Leaf curl and chili veinal virus, CMV. Virus complexes
  - o Helicoverpa
  - o (Spider) mites
  - o Aphid

Pest survey/monitoring for Capsicum/Chilli; This year and will decide on the packages next year.

- Beans – pole, French, country (Lablab)
  - o Rust
  - o Aphids
  - o Anthracnose
  - o Pod borer
  - o Flower weevil
  - o Bruchids
  - o Root rot
  - o Sclerotium collar rot
  - o Virus – BCMV, yellow mosaic (lablab)
  - o Stem weevil
  - o Leafminer
  - o Sclerotinia white mold

*New technologies/components*

- Anaerobic Soil Disinfestation (ASD)
  - o Needs research – NARC and Ram (OSU)
  - o Mustard cake as a carbon source
  - o Rice Bran/Husk or something similar carbon source (Molasses if available)

- Mustard cake for nematode control in greenhouses – technology already available: Later as a comparison
- Onion pest monitoring
- Eggplant -- EFSB
  - o Area wide lures
  - o Clipping shoots
  - o Applying pesticides (Spinosad and Corragin ) in 3 weeks interval after first visual symptoms of pest: Will add this component to our package that we already have. – Need PERSUAP
  - o Keeping track of cost involved and the benefits is very important!
  - o Next season we can test in Banke!
- Tomato pith necrosis - polyculture
  - o Tomato surgery – remove infected pith and paint wound with copper oxychloride
  - o Reduce nitrogen
  - o Sanitize tools with bleach during clipping
  - o It can go right into our package
- *Fruit flies for cucurbits and bittergourd*
  - o Protein bait – Russell IPM
  - o Cuelure
  - o Economics will be important to look into for Protein Bait
  - o Dr. Muni and Dr. Rajotte will follow with scientist (ISCA and Graham)
  - o We can check with "DAHAL TRADING" and we will decide on whether we can integrate with our package this year.
  - o RP will check if he will be able to give some samples to IPM IL
- *Capsicum Phytophthora blight*
  - o Raised beds
  - o Compost amended with Trichoderma and Pseudomonas
  - o Resistant varieties/grafting
    - *Pest survey/monitoring for Capsicum/Chilli; This year and will decide on the packages next year.*
- *Virus*
  - o Diagnostics (Cristina contact)
  - ☐ *Send kits to NARC*
  - ☐ Mechanical inoculation on indicator plants eg tobacco

Design a facility at NARC for proper identification/diagnosis of virus/ developing protocol  
 Roguing; one of the best practice in nurseries  
 Developing capacity of NARC and other related stakeholders
- *Tuta absoluta*
  - o Detection
  - o Field survey
  - o Pheromone traps

Sulav will coordinate with Bio-control research lab to get few Tuta pheromones.  
 When Tuta enters Nepal, the first strategy will be to go with chemical pesticides and then later we can look for other eco-friendly approach.

*Using mass media (FM, TV) to create awareness*

*Bt plus Neem could be one option.*

*Intensifying monitoring at different elevations once Tuta enters Nepal*

- Lyriomyza
  - o Large yellow sticky trap can be integrated into our package
- Mass biocontrol release
  - o Trichogramma
  - o Chrysoperla

Results of discussion on collaboration across all the partners: IPM has history in Nepal since first BPH program in 1998. Since then FAO has been involved in supporting it. IPM has been in National Agricultural Policy since 2006. The challenge with vegetable IPM is mass awareness at the local level. FAO program in 5 districts. No price incentives for IPM adoption, but collection centers are key for certifying healthy product so there can be. There is also a problem with free products holding back private sector involvement on inputs and quality control is a problem and cost of bio-pesticides. Availability of products a problem. Issue of steps it would take to gain IPM certification were discussed. There was a lively discussion about the need to involve NARC and its scientists in the IPM program and not just DOA. The National Plant Protection Organization needs to be involved led by PPD. The NARC Plant Pathology Head said that would like to be more involved in the National IPM program. Key issues discussed were knowledge dissemination, policy issues, mainstreaming IPM, and supply chain to scale up. *It was decided that a small working group for the National IPM Program needs to be established with representatives from PPD, NARC, DOA, CEAPRED, FAO, and private sector. It was set up and will have first meeting the first week in March. There should also be a national technical working group in NARC. The IPM IL can also work in a pilot program in Rangan (Lalitpur) to have the 60 farmers there obtain voluntary self-labelling IPM certificate. It will be set up by PPD. Also, KISAN will apply the approach.*

A chart of how all the groups will tie together was presented.

Maria Elisa met with two gender specialists at iDE, Sabita Yadav and Niki Maskey, to explore possible collaboration on gender research. Sabita is responsible for a project: "Enhancing livelihoods for farmers" funded by DFID and she is focal person for gender and the goat sub-sector. She has an MSc in sociology from Tribhubvan University and gender training in Thailand, Vietnam, and the Netherlands. She is responsible for gender work on the PAHAL (Promoting Agricultural Health and Alternative Livelihoods) project, funded by USAID. Niki is the project coordinator of BRACED- (Building Resilience and Adaptation to Climate Extremes and Disasters) and is the gender focal person for the project. She studied Environmental Studies and Sustainability Science in Lund University, Sweden and has worked as a research officer for gender and climate at the IWMI Nepal office (Int'l Water Mgt Institute). IWMI did a WEAI (Women's Empowerment in Agriculture Index) baseline and will be analyzing it shortly. She will do qualitative work also, to support facts and figures. Maria Elisa will share information about how she used the WEAI in Cambodia. Gender research in Surkhet District where IPM IL plans to work in this phase will overlap with where the two BRACED and PAHAL projects are doing gender work, which should allow for synergies.

February 5: Field trip to Lalitpur

Two women's groups (36 farmers) and a vegetable collection center were visited. They produce tomato, bitter gourd, cole crops, and others. No longer use pesticides. They say they are empowered through savings, more decision making, more knowledge, and greater market access. These groups were helped by iDE after the earthquake. A community Business facilitator said she has seasonal profits of 4000- 5000 rupies/month in season and 2000-2500 out of season. Mostly sells seeds, bio-

products, and drip irrigation. She sells to 25 groups (about 500 farmers). She has monthly meetings and talks. Farmers call and she brings products to their houses. She buys products from various agrovets. She received training from iDE USAID project. She is also a farmer. One farmer had solar pump (Cost \$400).

Collection center: Farmers use IPM. 2500 kg per collection. 4000-4500 kg/collection at peak. Have been operating for the past 1.5 years. No pesticides used. Many vegetables: tomato, cucumber, cauliflower. The trader there said customers seek him out because he has pesticide-free produce, but he does not receive higher prices at this point. Needs a building.

After lunch, Maria Elisa left to return to the States and the group went to NARC. We visited with Dr. Prem Sharma, head of entomology and Ram Prasad, who presented a summary of their program in the Entomology Division. George Norton summarized the IPM IL program. They are interested in collaboration. We visited their biocontrol lab and then visited the Plant pathology Division. The Department Head, Dr. Baidya Mahto explained that the research in NARC was split from the rest of DOA in 1991. There are 58 scientists in the Plant Path division. They use MOUs to work with other projects. They focus a lot on vegetables. Has lab that can do diagnostic tests. Very concerned about seed-transmitted viruses.

Later in the afternoon, we went to the Department of Agriculture and visited Dr. Yubak Dhoj, the Director General. DOA has 184 offices and 6000 staff. The extension program under DOA has 5 regional offices for plant protection. He is worried about white flies and also wants mass production of insect parasitic nematodes. He favors use of bio-pesticides, but there is a lack of commercial-scale production. Would to see the project work with private companies to get it done.

iDE hosted a dinner in the evening for the whole IPM IL group.

*February 6:* Norton met with sandwich student Arjun Khanel about his dissertation. Baseline survey was discussed for Banke and Surket. Sample selection and questionnaire were discussed

Group was transported to airport to return to the States (except Muniappan who went to India).

*February 7-9:* arrive in the U.S.

#### **Suggestions, Recommendations, and/or Follow-up Items:**

- Kimhian will revise workplan with more details and send to U.S. group for comments. Field work will center in Siem Reap, Battambang, and RUA (near Phenom Penh).
- Need to ask Ngin Chhay to serve on two-person advisory council and decide who to ask at RUA to serve on it.
- BARI scientists will send revised research activity proposals to Yousuf who will send them to the U.S. scientists for review. Need to also include mango research activity.
- Need to involve students at University of Dhaka more in the field work with BARI scientists.
- Norton will send drafts of baseline surveys to Cambodia and work with Arjun on one for Nepal. Norton will coordinate with Cornell and possibility IFPRI on Bt eggplant survey.

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Appendix for Cambodia:

<b>IPM Package Components (Some not available yet in Cambodia) for crucifers</b>	<b>Insects</b>	<b>Diseases</b>	<b>Weeds</b>
Select pest-free, healthy seeds/sanitizing seed treatment		X	X
Seedbed solarization, Anaerobic Soil Disinfestation (ASD)	X	X	X
Raising seedlings in trays with artificial growth medium/sterilized/clean soil		X	X
Nursery nets for insect exclusion	X	X	
<i>Trichoderma spp.</i> , <i>B. subtilis</i> seed & plant		X	
Roguing for black rot management in field		X	
Liming, <i>Trichoderma</i> for clubroot management		X	
Pheromone traps to monitor pests such as <i>DBM</i> , <i>Spodoptera</i>	X		
Yellow sticky traps for aphids and leaf miners	X	X	
Trap crops for DBM eg mustard	X	X	
Microbial pesticides such as <i>B. bassiana</i> , <i>M. anisopliae</i> , <i>Bacillus thuringiensis</i> , <i>Paecilomyces sp.</i> , nuclear polyhedrosis virus (NPV)	X		
Biopesticides such as neem and other botanicals	X		
Inundative release of <i>Trichogramma spp.</i> , <i>Hebrobracon hebetor</i> and <i>Chrysoperla spp</i> (future option?)	X		
Conservation biological control/maintaining beneficial insect habitat (flowering plants)	X		
Cultural practices: staking, pruning, mulching, raised beds		X	

<b>IPM Package Components (Some not available yet in Cambodia) for cucumber</b>	<b>Insects</b>	<b>Diseases</b>	<b>Weeds</b>
Select pest-free, healthy seeds/sanitizing seed treatment (?)		x	x
Field and growth medium solarization, Anaerobic Soil Disinfestation (ASD)	x	x	x
Raising seedlings in bags with artificial growth medium/sterilized/clean soil		x	x
Fruit fly mass trapping - Cuelure	x		
Nursery nets for insect (virus vector) exclusion	X	X	
<i>Trichoderma spp.</i> , <i>B. subtilis</i> seed & plant		x	
Roguing seedlings to eliminate pathogens		x	
Yellow sticky traps for aphids and leaf miners	x	x	
Downy mildew/powdery mildew fungicide selection		x	
Microbial pesticides such as <i>B. bassiana</i> , <i>M. anisopliae</i> , <i>Bacillus thuringiensis</i> , <i>Paecilomyces sp.</i> , nuclear polyhedrosis virus (NPV)	x		
Biopesticides such as neem and other botanicals	x		
Inundative release of <i>Trichogramma spp.</i> , <i>Hebrobracon hebetor</i> and <i>Chrysoperla spp</i> (future option?)	x		
Conservation biological control/maintaining beneficial insect habitat	x		
Cultural practices: staking, pruning, mulching, raised beds, fruit bagging (bitter gourd only)		X	
Live barriers / protected culture (?)			

<b>IPM Package Components (Some not available yet in Cambodia) for Tomato</b>	<b>Insects</b>	<b>Diseases</b>	<b>Weeds</b>
Select pest-free, healthy seeds/sanitizing seed treatment (?)		x	x
Seedbed solarization, Anaerobic Soil Disinfestation (ASD)	x	x	x
Raising seedlings in trays with artificial growth medium/sterilized/clean soil		x	x
Nursery nets for insect (virus vector) exclusion	X	X	
<i>Trichoderma spp.</i> , <i>B. subtilis</i> seed & plant		x	
Roguing seedlings to eliminate pathogens		x	
Grafting on resistant rootstock to reduce soil borne diseases eg bacterial wilt and RKN, using resistant cultivars		x	
Pheromone traps to monitor pests such as <i>H. armigera</i>	x		
Yellow sticky traps for aphids and leaf miners	x	x	
Intercropping eg Chrysanthemum trap crops for nematodes and <i>H. armigera</i>	x	x	
Microbial pesticides such as <i>B. bassiana</i> , <i>M. anisopliae</i> , <i>Bacillus thuringiensis</i> , <i>Paecilomyces sp.</i> , nuclear polyhedrosis virus (NPV)	x		
Biopesticides such as neem and other botanicals	x		
Inundative release of <i>Trichogramma spp.</i> , <i>Hebrobracon hebetor</i> and <i>Chrysoperla spp</i> (future option?)	x		
Conservation biological control/maintaining beneficial insect habitat	x		
Cultural practices: staking, pruning, mulching, raised beds		X	
Live barriers / protected culture (?)			

<b>IPM Package Components (Some not available yet in Cambodia) for yard long bean</b>	<b>Insects</b>	<b>Diseases</b>	<b>Weeds</b>
Select pest-free, healthy seeds/sanitizing seed treatment (?)		X	X
Field solarization, ASD?	X	X	X
<i>Trichoderma spp.</i> , <i>B. subtilis</i> seed & plant		X	
Roguing to eliminate pathogens		X	
Pheromone traps to monitor pests such as <i>Maruca</i>	X		
Yellow sticky traps for aphids and leaf miners	X	X	
Microbial pesticides such as <i>B. bassiana</i> , <i>M. anisopliae</i> , <i>Bacillus thuringiensis</i> , <i>Paecilomyces sp.</i> , nuclear polyhedrosis virus (NPV)	X		
Biopesticides such as neem and other botanicals	X		
Inundative release of <i>Trichogramma spp.</i> , <i>Hebrobracon hebetor</i> and <i>Chrysoperla spp</i> (future option?)	X		
Conservation biological control/maintaining beneficial insect habitat	X		
Cultural practices: trellising, pruning, mulching, raised beds (wet season); remove infested flowers		X	