East African Vegetable IPM Trip

Report Countries Visited: Kenya,

Tanzania, Ethiopia **Dates of Travel**: 27

March – 7 April, 2016

Travelers Names and Affiliations: John Cardina, Celeste Welty, Mark Erbaugh, R. Muniappan, and George Norton (Virginia Tech); Brhane Gebrekidan. (Regional IPM-IL Coordinator).

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

Sites Visited: Nairobi, Thika (KALRO, Kenya Agricultural and Livestock Research Organization), KAVES (Kenya Agricultural Value Chain Enterprises Project);
Dar es Salaam, MARI (Mikocheni Agricultural Research Institute); NAFAKA (Staples Value Chain Activity, USAID FtF contractor for FtF)
Addis Ababa, Hawassa University, Hawassa; State Bureau of Agricultural and Natural Resource Development, Hawassa; Ziway Plant Health Clinic.

Gender Distribution of Contacts:

	Ethiopia	Kenya	Tanzania
Female	1	6	4
Male	4	6	7

Description of

Activities/Observations: 27 March:

U.S. scientists left United States

28 March: Arrive 11:00 p.m. in Nairobi via Paris.

29 March: Nairobi-
8:30 a.m. Meeting at KALRO with Cecilia (representing Jesca Mbaka), Joel, Tadele Tefera (ICIPE; PI of the Grains IPM-IL), Miriam H., Dr. Lusike Wasilwa, Director Crop Systems KALRO Secretariat.
We were later joined by Dr. Kambo, entomologist, and Beth Ndungu, gender specialist.

Lusike took charge of the meeting. She gave an account of the recent history and reorganization of KALRO. Since 2013 the attempt has been to have a more coordinated research system. Several existing research institutes, including Tea Research, Coffee Research, and Sugar research, have been combined to make up KALRO; however, some institutes have not joined.

The hope is that with better coordination, research results could be delivered more effectively. They realize now that the amount of coordination is not the limitation, but support for activities is what determines their success. They currently get little government support.

There are now 16 commodities that are the focus of the Horticulture Crops Research Institute. Under the 16 research areas are 51 centers. Kenya has 47 counties; KALRO is in each county. The headquarters is called the "Secretariat", and Lusike heads the Crops Directorate, coordinating horticulture and industrial crops, plus food crops, tea, coffee, and sugar. Crops are the focus of 80% of the scientists, the remainder being livestock. Lacking government support, they are looking for industry funds to support research.

The team met in a different conference room to discuss priority crops and pests. Attendees were as follows:
Dr. Jesca Mbaka – Leader, Plant Pathologist, and co-PI; Caeser Kambo - Entomologist; Dr. Beth Ndungu - Gender expert; Sylvia Kuria - Pathologist; Charity Gathambiri - Post harvest physiologist; John Cardina, George Norton, Celeste Welty, R. Muniappan, Tadele Tefera, Cecilia ( ), Charles Nderito, Henry Wainwright, Patrick ( ) and Margaret ( ) – RealIPM.

During introductions, R. Muniappan gave a brief history of the IPM-IL project and explained the work of the RCSP in Kenya since 2005. He mentioned other IPM-IL projects for Grain Crops led by ICIPE and the Parthenium project led by Virginia State.

George Norton spoke briefly about the baseline farm survey, including knowledge of pests and pest management practices. He is aiming to get 400 farmer surveys per country, at a rate of about 20 households per day. The focus will be on areas where vegetable production is important, where they will randomize villages, farms, and farmers. Gender questions will be included in the survey. At this point there is a need to determine who will be able to help carry out the survey in Kenya.

Miram spoke about the plant clinics where extension staff are located. There are 21 clinics. They operate twice per month for pest and disease diagnosis. This provides real-time diagnosis. They make use of images for detection when necessary. There are "green" and "yellow" lists indicating severity. The biggest emphasis is on IPM, biocontrols.

CABI (?) wants to start with diagnosis, which is seen as a big challenge. CABI cooperates with KALRO in this plant ID effort. The participants have ipods and relay images to various labs to get diagnosis in near-real time. (See KALRO website for images). They believe these images are better than a fact sheet because of the many views and color and different images for a given pest or disease symptom. With the access to digital data they are thinking of including maps to follow the progress of a pest.
Pest clinics are established in village areas so people can bring samples to the village where a "plant doctor" will be stationed. "Demand-driven research and training" is the goal. Hort crop scouts are trained to work with the county.

Tadele gave a brief description of the Grains IPM-IL. The project involves chickpea in Ethiopia, rice in Tanzania, and maize in Kenya. These crops were chosen by USAID. They will begin with a baseline survey to prioritize the pests issues, and involve farmers in the survey. The project aims to develop diagnostic capacity using mobiles to identify pests. They are working with William Hansen at Univ. MN for images of weeds. They will provide capacity building using field schools and training centers. They hope to address policy factors that favor or disfavor IPM development and adoption.

Cecilia, standing in for Jesca, emphasized work on pest – mostly pathogen and disease – diagnostics. She described a workshop last year as well as development of outreach materials. She mentioned as well the use of entomopathogenic nematodes, some of which are a source of toxins that might be developed as biological control agents. A discussion ensued about Real-IPM and Dudutek as sources of these nematodes. They apparently are not selling these to farmers, but this represents a potential market.

The group met with Dr. Charles Waturu, entomologist and nematologist, and HRI Director, who gave us a brief welcome and introduction to KALRO. He spoke of the 16 institutes headed by Directors. HRI is one of the Institutes. HRI has 4 Centers, including KALRO Kandara, the one that Jesca Mbaka heads. He mentioned that they are just starting this organizational arrangement. There is a problem of lack of funds. There is a government embargo on employment, leading to an aging staff and few young people entering the system. He is familiar with the previous CRSP project. He has a history with the project and

outcomes. He mentioned that there are things that can be done without money: outreach materials can be developed by people working with computers from their desks, as one example. Dr Waturu mentioned a desire to develop diagnostics capabilities. He indicated a World Bank project that might support this.

Henry Wainwright from Real IPM introduced his colleagues, Patrick (IT expert) and Margaret (product trials technical support). Henry indicated that WhatsApp technology is more or less free for Kenyans, and that ~75% of farmers have it on their phones. Data including images and video can be sent to groups as well as individuals. Such data can be sent to a central hub for diagnosis support. He offered that HRI could be a hub for diagnostic expertise. This arrangement has yet to be made and it is not clear at this point who is willing to provide services as a central hub for images, queries etc.
Henry indicated that information can go both ways, i.e. information can go out to farmers as an early warning system.

Jesca Mbaka, co-PI and Center Director, joined the meeting at this point.

Tadele suggested the possibility of having joint training for the two IPM-IL projects. In other words, if we do a diagnostic workshop for vegetables, linking in participants from the grains IPM-IL.

At this point we focused on identifying priority crops and their pests. Notes of salient discussion appears below along with a table that summarizes the discussion and points out individuals responsible for studies of interest.

Jesca: Prioritize these three - Tomato; beans, cabbage; (previous 10 years of IPM IL worked on tomato and onions).
If possible to add another, add Chilies: false codling moth emerging problem.
If onion included – onion thrips; purple blotch; downy mildew depending on zone

Suggested that we not handle more than 3 crops ; must focus on crops from one area; can't do trials all over the country; focus on FtF area – east or western; eastern is closer. Farmers don't specialize in one crop. Alternate tomato with French beans.

Tomato:
Tomatoes and all crops on list are irrigated not rainfed; they are planted all year-round. Prices go up in the rainy season when diseases are a problem. Two rainy seasons: Apr-May and November.
Round variety tomatoes are considered higher value; Kenyans generally grow the plum shaped type in the field. Irrigation is usually drip in greenhouses; in the field they rarely use drip, but rather usually use furrow irrigation. Most tomatoes in the field are determinant varieties and are staked; indeterminate varieties are grown in greenhouses. Greenhouse and field tomatoes have different needs. Greenhouse growers have a bigger investment; they grow indeterminate, higher values seedlings.

First suggestion of priorities: bacterial wilt, spider mites; nematodes,
Producing disease free seedlings; raising seedlings in nurseries is a business.
Problem with GH production: fashionable but there is a lack of technical know-how. Not much research to be done for GH; the main need is outreach training. Mostly need training in establishment of pathogen free seedlings in germination trays.

Trichoderma, biopesticides: Henry suggested a need for monitoring and scouting; traps, pheromone traps; anticipation and planning etc. There is a range of products that could be used.
For tomato seedling production, farmers need training; for example, in the use of trichoderma and other bioconrols that are effective. These are available to small scale farmers. Need training not research.

Nursery nets to keep whiteflies out as virus vectors. Might need demonstration, training. Also teaching what Tuta infestation looks like in seedlings.

Bacterial wilt – number one problem in tomato. Widespread in tomato growing areas; also in potatoes; this is of course a soil-borne disease. Occurs both in field and greenhouse. Can't eliminate it once it is in the soil. (Earlier phase of IPM-IL in Kenya used grafting with BW resistant rootstocks and soil solarization to manage BW).Could use grafted plants, or grow in pots or bags in greenhouse. Half of the tunnels can't grow tomatoes anymore because of BW. MT56 is only resistant rootstock known or available.

Sylvia suggested that maybe Trichoderma will help. Need research on this. She suggested a need to screen more rootstocks for tolerance.

Trichoderma spp. and Bacillus subtilis should be tested.
There are many strains of bacterial wilt pathogens. They are regionally variable.
Propagation of seedlings using river irrigation water will add BW to the soil.
Grafting with MT56 is not always successful. Graft height is important; if graft is too low, the soil-borne pathogen can get into the plant. Also there are problems with incompatibility if rootstock and scion are not same size.

Sylvia will take on this research.

Tuta absoluta: Could set up traps for monitoring and for mass trapping (for greenhouse). Tuta came originally from South America, then to eastern Spain in 2006, from which it spread to Ethiopia before coming to Kenya. It has apparently declined in importance. Not sure why – this could be due to natural control, or due to extensive spraying over a few growing seasons, before resistance has built up. Might be declining in Kenya. Henry thinks it has declined in Kenya. It is here but not as intensive as it once was. Spraying multiple times per season has been the practice, but the fear now is resistance to insecticides. Most popular insecticide is $300 per acre. Margaret (Real IPM) does R&D trials in tomato: it was a problem last 2 yrs. She thinks is seems to be declining.

There are natural enemies but pesticides disrupt the system. Farmers spray every 3 days. Henry thinks it has declined not only because of spraying. Something is going on that is not understood.
Corrigen is used frequently. In Nepal, they are trying neem, biopesticides. In Egypt, Bacillus thuringiensis, Artemisia cina extract, clove oil and nanosilica were tested in a greenhouse. Nanosilica was the effective as was Artemisia cina extract, as well as combinations with insecticides imidacloprid and indoxacarb. {See: African Entomology 20(1):27-34. 2012. Some Recent Approaches to Control Tuta absoluta in Tomato Under Greenhouse Conditions. A.S. Derbalah, S.Z. Morsey, & M. El-Samahy.}

Tomatoes in Kenya in field most are determinant and are staked. What is feasibility of row covers? The tuta can go underneath.

Jesca: some companies trying to bring some biopesticides. Only one resgtered pesticide: Belt. In US, "Belt" cancelled; might not be same chemical. Can still use neem; BT, spinosad.
Could try some of these in a demo in a way to get research data.

In a biological survey it will be important to explore whether Tuta is actually a problem.

For tomato viruses: Rogueging is used to manage them once symptoms are apparent.

Seedbed solarization is used in greenhouses. Done by a few people. It is seasonal; can work on sunny days but not in rainy season.

Other pest problems: Phythophthora; White flies; Helicoverpa; bollworm; seasonable. Not predictable. Use Bt and neem-based products. NPV available.

HW suggest: demonstration of the various biocontrols. Use all the tools as need be; scout every week. This is better for unpredictable insects. Real IPM has demo trial underway with their products.
Randomize plots within an area.
Tomato: seed trts trich and bascillus;
In the field: Metarhizium 62, 69, 78 for different pests; e.g. M-69 formulated inoil works on whiteflies.once a week or once every 2 weeks.
Bascillus subtillus for powdery mildew and rust.
Predatory mites: etc; see Real IPM catalog for possible biocontrols.
Four Bts registered in Kenya.
MPV: hellitec;
HW will give data from RI trials.
Are predatory mites realistic for small holders? Effective in demo site but might not be useful if transport over 24 hr.

Metamix is packaged for smallholder. Multiple organisms; sprayed once a week. Not yet registered in Kenya. Some registered in Tanzania but not as much as Kenya. Ethiopia is considered more problematic for field use.
If compare with cost of insecticide: "it certainly won't be more expensive" (HW).

Tedale: Wnet to min of agric. Need to work with national programs. The app goes to the ministry. Then can import and use only on confined area. Support of greenhouse but no clear direction.
NPV- specific beneficial virus.

Sylvia: use MT-56;
RealIPM will do demo on bioproducts.

Bacterial wilt, white fly: Kuombo can do specific experiments on specific insects and products. Many chemicals on whiteflies with insecticides; need research on Metarhizium 69 formulated in oil.
Some others for comparison?

Fusarium wilt; not considered common, but there likely a problem diagnosing it.
Rootknot nematodes: U. Hawaii released resistant varieties. Even if resistant varieties exist, the market will determine the variety chosen. Trichoderma controls RK-nematode.
Neem products available. The oils and extracts are available. They are variable in performance. Neem trees grow along the coast. Someone could collect seeds, put them in water over night and spray.
For weeds: Mulching with rice husks; Available. Need a layer a centimeter thick, but this will not suppress large-seeded weeds or perennials. Rice grown around areas where tomatoes are grown. Rice weeds come in with the rice husks. Black plastic mulch is considered too expensive. High UV light degrades the plastic. Banana leaves can be used as a mulch to suppress weeds for small areas.

HW: Suggest an IPM booklet starting to put together and improve each year. So by year 4, have an output that describes IPM for tomatoes.
Training: For use of trihoderma: already producing it at RealIPM; do we need more training?
HW: Demo of his products brings a lot of farmers.

RealIPM will do training for farmers, going through the package and all possible biocontrols.
To train extension workers that's for KALRO and VT and OSU;

Cabbage:
Diamondback moth (DBM), black rot are main problems.For blackrot, need healthy, clean seeds; Bacillus subtilis might help. Suggest experiment with trichoderma, B subtills for black rot. Also BT and pheromone traps. The "Delta trap" is used for mass trapping of several insects.
Need a demo trial for trap crops.
Nets for DBM and other moths; not for thrips, white flies.
Jesca will do a test on trichoderma for black rot and club root. Henry has not seen black rot.
Consider using lime to raise pH, as club root prefers acid soils.
Tests needed for DBM: Neem might be used as a repellant for DBM; Celeste suggested that Bt is better.
Conservation biocontrol, maintaining habitat for beneficials has not been studied. It did not sound like there's much interest in this, which might suggest that it needs to be studied.
Microbial pesticides need to be tested for DBM, e.g. Beauveria, Metarhizium anisopliae, BT, Paecilomyces.
Also for aphids – e.g. Metarhizium 62. Kambo will do this..

Margaret: postharvest problems are a concern for many crops; drying of cabbages is a practice used.

Jesca suggested that during the baseline we need to verify what the pests of concern are in each geographical area.
GN: Crop pest monitoring needs to go on.

Jesca: baseline survey is situational analysis. The crops, problems, gender issues etc. Suggest doing testing on station initially, then in field after data have been generated to show it works.

Beth needs to be involved with survey, in formulating questions. George N and Beth to coordinate this; also Mark Erbaugh. George N is working on a standard survey to be used across countries.

Tadele: would like to use same/similar survey for grains. Will link George N with his socioeconomist; not only for survey, but also for any workshops.

French beans:
Priority pests: bean fly; the ecology/biology needs to be studies. Tadele suggested that there are already several studies. Review this literature.
White flies: microbial pesticides (maybe synergy with tomato); Muriuki will do testing. Also for Thrips and black bean aphid.
Rust is a major disease of beans. There are resistant varieties.
Postharvest botrytis remains a problem.
The legume pod borer, Maruca vitrata, is a pantropical pest on leguminous crops. Some pheromones are available. Biopesticides, neem other botanicals : Cecilia will do this test.
Rootknot nematodes: record in all treatments to see if there's an impact.

Onion:
Onion (dry bulb) – raised in nursery and transplanted.
Thrips are significant pest; netting won't work for this. Metarhizium 69 can be used for thrips. Need to test. Any existing data? Icipie might be source of data on endophyte studies. Need a literature search.
Pythium, damping off: Trichoderma could be tested for this.

Downy mildew: some reports trichoderma helps with this. Endophyte goes into plant and plant responds as though it is being attached.
Erwinia soft rot is a big problem postharvest; often improper curing of the onions; The Tanzanian onions cure well. Harvest time should be after leaves have died down; if harvested too early, they don't cure well.

Chillies:
Production system similar to tomato. No grafting for chillies.
Fruit fly: this needs to be monitored.
False codling moth FCM: there's a pheromone trap for it but not sure it is in Kenya. Monitor.
Yellow sticky traps for aphids.
Broad mite: californicus parsitizes it. Metarhizium 78 used for mites; Muriuki will test this.
Viruses- spread by thrips, white flies.

Real IPM will provide free product for the project to KALRO for testing. In return, they would like to check the protocols to be sure the product will be used correctly. Also would like access to the data. Real IPM will not put barriers to publication.

Below is a summary table of priority pests of vegetable crops in Kenya.

IPM Package Components for crucifers	Insects	Diseases	Weeds
Select pest-free, healthy seeds/sanitizing seed treatment		X	x
Soil 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	
Trichoderma spp., B. subtilis seed & plant (black rot)		Test (Jesica)	
Liming, *Trichoderma* for clubroot management		Test (Jesica)	
Pheromone traps to mass trap *DBM*	x		
Yellow sticky traps for cabbage aphids	x	X	
Trap crops for DBM eg mustard	x	X	
Microbial pesticides such as *B. bassiana, M. anisopliae, Bacillus thuringiensis, Paecilomyces sp. For DBM, aphids*	x	Test (Kambo)	
Biopesticides such as neem and other botanicals	x		
Conservation biological control/maintaining beneficial insect habitat (flowering plants)	x		
Cultural practices: mulching, raised beds		X	

IPM Package Components for Tomato	Insects	Diseases	Weeds
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 for transplanting in the field		x	x
Nursery nets for insect (virus vector) exclusion	X	X	
Trichoderma spp., B. subtilis 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 (Silvia will need to test rootstocks)		Test (Sylvia)	
Pheromone traps to monitor pests such as *H. armigera*	X		
Yellow sticky traps for aphids and leaf miners	X	X	
Intercropping eg Chrysanthemum trap crops for nematodes	X	X	

and *H. armigera*			
Microbial pesticides such as *B. bassiana, M. anisopliae, Bacillus thuringiensis, Paecilomyces sp.*, Metarhizium	X		
Biopesticides such as neem and other botanicals for Tuta absoluta, helicoverpa	Test (Kanbo) Spelling?		
Inundative release of *Trichogramma spp., Hebrobracon hebetor* and *Chrysoperla spp* (future option?)	x		
Conservation biological control/maintaining beneficial insect habitat	x		
Cultural practices: staking, pruning, mulching, raised beds		X	X
Live barriers / protected culture (?)			

IPM Package Components for beans	**Insects**	**Diseases**	**Weeds**
Select pest-free, healthy seeds/sanitizing seed treatment		X	x
Field solarization, ASD? (Sally?)	x	X	x
Trichoderma spp., B. subtilis seed & plant		X	
Roguing to eliminate pathogens and viruses		X	
Pheromone traps to monitor pests such as *Maruca*	x		
Yellow sticky traps for aphids, thrips, and leaf miners	x	X	
Microbial pesticides such as *B. bassiana, M. anisopliae, Bacillus thuringiensis, Paecilomyces sp for white flies, thrips, black bean aphid, bean rust*	x	Test (Muriuki)	
Resistant varieties for rust			
Biopesticides such as neem and other botanicals for *Maruca*	x	Test (Cecilia)	
Cultural practices: mulching, raised beds (wet season)		X	

IPM Package Components for Onion	**Insects**	**Diseases**	**Weeds**
Select pest-free, healthy seeds/sanitizing seed treatment (?)		X	x
Field and growth medium solarization,	x	X	x
Trichoderma spp., B. subtilis seedbed, field		X	
Microbial pesticides such as *B. bassiana, M. anisopliae for thrips*	x	Check literature (Kambo)	
Biopesticides such as neem and other botanicals	x		

Curing at recommended temperature and days			

IPM Package Components for Chili peppers	**Insects**	**Diseases**	**Weeds**
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	
Trichoderma spp., B. subtilis seed & plant		x	
Roguing seedlings to eliminate pathogens		x	
Pheromone traps to monitor pests such as FCM (false codling moth), fruit fly	x		
Yellow sticky traps for aphids	x		
Predatory mites	Test (Muriuki)		
Microbial pesticides such as *B. bassiana, M. anisopliae, Paecilomyces sp.*,	x		
Biopesticides such as neem and other botanicals	x		
Conservation biological control/maintaining beneficial insect habitat	x		
Cultural practices: mulching, raised beds		X	

On Wednesday 30 March we departed for the American Embassy at 9:00. After waiting, we were informed that our contact was not available to meet with us.

In the afternoon, we visited the Kenya Agricultural Value Chain Enterprises (KAVES) project at Karen Office Park, Langata Road. We met with Mulinge Mukumbu, Deputy Director, and George Adem Odingo, Technical director for maize and food crops. KAVES is a USAID-supported project initiated in 2013 to support commercialization of smallholder agriculture. They work in 22 counties in western and eastern Kenya. They discussed the horticulture crop value chain, especially French beans. Pesticide residues remain a challenge for the export market. They have worked with Real IPM on PERSUAP applications, and have also worked with KALRO. They are interested primarily in the private sector, not research. They work with the providers of technology. In other words, they are developing delivery systems for technologies, delivering technologies to farmers when need and at a good price. They are not interested in a technology unless there is an established supply chain and private sector that can deliver the technology. They work mainly through field days and trade fairs to promote new technology that has private sector backing. They are effective at getting farmers to field days, which they believe has more impact than small demonstrations. Field days and trade fairs bring players in the value chain together. For example, they held a French bean field day that brought out not only growers, but also processors, fertilizer companies, seed companies. They run field days at the county level for many crops or a focused field day for one commodity.
The focus is on FtF counties (22 out of 47) except arid areas. They work with extension, giving them leadership in mobilizing farmers and giving them the opportunity to coordinate the event.
Labor is challenging for small farmers: the wife and children are called on for labor; they need labor saving devices, equipment etc. For example, maize shelling by small machines instead of by hand. Weeding now depends on hoeing and herbicides; they wish they had alternatives.
In their view, one needs 15ha to have a livelihood in agriculture. Herbicide use is peaking. Seedling production is a new enterprise; there are some government registered nurseries. They are not encouraging maize production because it is such a low value crop. Maize requires about 15 acres to be profitable. They encourage farmers to grow maize for the family's needs in a small area, and then use the rest of the area for high value crops. In hort crops, pesticide sprays are the main input to production.

31 March: Dar es Salaam, Tanzania –
We visited Mikocheni Agricultural Research Institute (MARI). We met with Andrew Ngereza and Peter Sserewagi. MARI was established in 1996 to conduct work on coconut. They focused on three areas: 1-coconut research; 2- tree crops and inter crops; and 3-biotechnology research, with a transformation labe, tissue culture lab, and diagnostics lab. Currently they collaborate with SUA and IITA.
The current mission is to develop and disseminate technologies and promote the use of biotechnology for crop improvement. They work in the areas of breeding/crop improvement, agronomy, socioeconomics, pest (i.e. insect) control, disease control, and biotechnology research. They showed us work on coconut embryo culture techniques and transformation work on cassava. We met with Charles Kayuki, lab manager for plant transformation work, and Dr. Christopher Materu, entomologist, who showed use very practical IPM expertise, especially for rhinoceros beetle. (They have also done characterization of tomato viruses).

In the afternoon we visited the NAFAKA Staples value chain activity, a component of USAID's FtF initiative in Tanzania. They are focusing on rice and maize value chains. We met with Thomas H. Carr, Chief of Party for NAFAKA. He is familiar with IPM and would like to be informed of workshops that could benefit smallholder farmers. They are focusing on Morogoro region and Zanzibar for work on rice, and Manyara, Morogoro, and Dodoma regions for maize. They have recently expanded into Mbeya and Iringa for both crops. He spoke of issues concerning adoption of new technologies, and the fact that new things are adopted and subsequently dropped. He suggested a need to study what makes adoption

successful. He noted that agriculture is still considered "old school" They have some youth spray programs that teach how to spray, mix, calibrate, and use safety equipment. They work with the private sector, much as KAVES does in Kenya. They still need training and this is where the IPM-IL can help, ie to bring in the expertise and NAFAKA will bring in people who need training. Also, if we want to get a new product out, NAFAKA can help through their many demonstration sites.

1April: Dar es Salaam – Meeting at Peacock Hotel with Project participants and guests.
Attendees:

John Cardina	Ohio State	Cardina.2@osu.edu
Elizabeth Maeda	USAID-Tanzania	emaeda@usaid.gov
Tadele Tefera	ICIPE-Ethiopia	ttefera@icipe.org
George Norton	Virginia Tech	gnorton@vt.edu
Hellen Kanyagha	SUA	hmbye@yahoo.com
Hosea D. Mtui	SUA	mtuihosea@yahoo.com
Amon P. Maerere	SUA	maerere@suanet.ac.tz
Delphina P. Mamiro	SUA	Mamirodelphi@gmail.com
Brhane Gebrekidan	Virginia Tech	bgebrekidan@gmail.com
Juma Shekidele	Horticultural Research and Training Institute	jsheiza@yahoo.co.uk
Celeste Welty	Ohio State	Welty.1@osu.edu
R. Muniappan	Virginia Tech	rmuni@vt.edu
Gration M. Rwegasira	SUA	grwegasira@suanet.ac.tz
Peter Sseruwagi	MARI	psseruwagi@yahoo.co.uk
Joseph Ndungu	MARI	jndunguru2003@yahoo.co.uk
Anthony P. Chamanga	TAHA	anthony.chamanga@taha.or.tz

After introductions around the table, Anthony Chamanga presented an overview of TAHA's activities. They are located in Arusha but operate in 15 regions. TAHA's overall objective is to reinforce and strengthen institutional capacities to help drive horticultural development for increased incomes, food and nutrition security in Tanzania. For industry technical strengthening they work in these areas: Policy analysis and advocacy; Technical support; Market information and marketing; Logistics and supply coordination; and Access to finance. For organizational capacity building and strengthening, they focus on these areas: Governance and management; Communications and outreach; Monitoring and evaluation; and Human resources development. They now have several thousand farmer members, most having joined in the past three years. Since 2013 over 25,000 farmers have received training in horticultural technology and GAPs. They work on all major crops. He has an interest in policy analysis. He sees a major challenge as Tuta absoluta, which has been a problem since 2013 and causes losses up to 80% or higher. Tuta is not such a problemin greenhouses,but this is due to many sprays. He is concerned about registration challenges for biologicals, and getting the right products to control the target pests. TAHA conducts training on pest management practices, pesticide use etc. They have their own training manual and extension team.

Juma Shekedele of Horticutlure Research and Training made a presentation on training and production activities at HORTI Tengeru. HORTI Tengeru is a government institution that was established in 1980. They train extension workers, resulting in Diploma of Horticulture; they also do training for farmers and extensionists. They have a capacity of 70 students. They have a partnership with USAID through TAPP and TAHA. In 2015 the IPM IL provided assistance with coolbot. Their curriculum is based on CBET, i.e. hands-on training at their Practical Training Center (PTC). The goal is to produce graduates who can

serve the extension sector. Students have 8 weeks of practical field training; they have 4 weeks of outreach where they are attached to farmers, projects, institutions. They get involved in farmer field days and in national events such as agriculture shows to help in the dissemination of technologies. The PTC was established in 2014 with help from the government, TAHA and TAPP. The challenges he sees are crop pests in their field plots; inadequate technical knowledge in horticulture; and lack of availability of some biological agents, including Trichoderma.

Amon Maerere gave an overview of Sokoine University of Agriculture (SUA) activities pertaining to past and present IPM work. For this new project, SUA will be a hub-site partner. They have good connections with public and private partners, including MARI, TAHA, SEVIA, MVIWATA. He suggested work in three target areas: Morogoro region, Iringa region, and Kilimanjaro region.

Peter Sseruwagi gave an overview of work at MARI, followed by a presentation by Joseph Ndungu about the need for greater research attention on viruses and their vectors in horticultural crops. He stated that losses of 20 to 100% are common for vegetables due to viruses. There has been little research to address this problem. He believes there is a need for a survey of viruses, their occurrence and distribution, especially on solanaceous crops, brassicacea, and legumes. The viruses need to be characterized using modern molecular techniques. He would like to have GIS maps of distribution. This affects where to screen, where to deploy new varieties. Currently, farmers apply mixes of up to 5 insecticides in several applications per week in an attempt to control viruses.

Delphina suggested that during a virus survey there is a need to train farmers so they understand why spraying insecticides on symptomatic infected plants will not help. She indicate that TPRI (Tropical Pesticide Research Institute) has a long list of pesticides.

We then initiated a discussion on the priority vegetable crops for Tanzania. We then discussed priority pests for each crop and IPM approaches that are being used and additional interventions that could be used. This discussion was organized around a structured table that was developed as follows:

CROP: TOMATO
Main pests: viruses, leafminer (*Tuta absoluta*), nematodes, seedling diseases

	SPECIFIC PRACTICE	WORK NEEDED
PRE-SEASON PLANNING		
Crop rotation	Non-solanaceous crop to suppress Tuta, fungal diseases, nematodes	
Resistant varieties	Nematode-tolerant varieties are available	
Seed selection	Select healthy seeds	
Host-free period	For tomato yellow leaf curl virus; unlikely to be practical	
PRE-PLANT ACTIVITIES		
Tillage	Deep plowing to control white grubs, Pythium, others	
Soil bed preparation	Raised beds in wet season	
	sunken beds in dry season	
SEEDING		
Seed treatment	treat seed with hot water	
	treat seed with sodium hypochlorite	
Planting media (in plug trays)	Pasteurized soil to suppress Pythium, seedling diseases	
	coconut dust to suppress Pythium, seedling diseases	
SEEDLING CARE		

Treatment of planting media??	Trichoderma for root diseases; Bacillus subtilis	
Seedling protection	Low tunnels	
	Netting for seedlings; agro-nets (?) to exclude whiteflies, aphids	
Grafting	MT56 to prevent bacterial wilt; or wild solanum?	**Mtui:** Evaluate grafting on wild solanum rootstock; work with Matt Kleinhenz on experimental design.
Roguing	Remove seedlings showing virus symptoms	
AT TRANSPLANTING		
Plug treatment	Dip plugs in Trichoderma for root disease management; *Bacillus subtilis*	
Transplant treatment	drench with slurry of beneficial microbes	**Delphina:** Study recipes for slurry and microbes (e.g. Trichoderma etc) to get consistent product.
CROP ESTABLISHMENT		
Staking	Yes	
Mulching	Rice husks, or straw; plastic in some areas; to suppress weeds, conserve moisture	
Sticky and pheromone traps	Pheromone for Tuta monitoring. Sticky for whiteflies, fruit flies.	
Pruning	Remove lower leaves to improve air movement to prevent fungal diseases	
Microbial controls	RealIPM has products that could be tested. Does Metarhizium have a place for insect control (foliar application)? Metarhizium-62 for aphids Metarhizium-69 for caterpillars & thrips; Metarhizium-69/oil for whiteflies; Metarhizium-78 for spider mites	
Botanical pesticides	Neem for several insects, though questionable efficacy.	
Conservation biocontrol	Avoid broad spectrum insecticides; Intercropping with marigold plants	
Irrigation	Do not use overhead irrigation in evening to minimize fungal diseases	
POST-HARVEST		
Fruit treatment	Sodium hypochlorite dip	**Mtui:** has worked with this; conduct studies or demonstrations.
Sanitation	Destroy plant debris to remove fungal inoculum	

CROP: ONION

Main pests: Thrips, purple blotch; weeds (Mexican poppy); downy mildew (esp in higher areas)

	SPECIFIC PRACTICE	WORK NEEDED
PRE-SEASON PLANNING		
Crop rotation	purple blotch, a seedborne disease.	
Seed selection	Select healthy seeds, treated with fungicides; Mexican poppy seed contamination; for seed certification this is a problem. Difficult to distinguish seeds.	
Variety selection	Resistant varieties needed but not available. Only 3 OP varieties, no resistance; texas grand. Some hybrids.	Need evaluation. **Dr. Mtui:** Evaluate onion varieties, hybrids for resistance, yield, quality etc.
Delayed planting	to escape disease; also helps capture different market.	**Delphina:** time of planting study;

		also include entomologist to look for time impact on disease and insect pests.
PRE-PLANT ACTIVITIES		
Tillage	Deep plowing for white grubs, Pythium, others	
Bed preparation	Raised beds in wet season, sunken beds in dry season.	
SEEDING		
Plug tray preparation	Pasteurized soil	
SEEDLING CARE		
Insect protection	repellent plants against thrips at seedling stage e.g. marigold, coriander,	
Netting	used for seedlings for thrips; might be OK at seedling stage, not convinced this will work for thrips (need ultra fine mesh).	
AT TRANSPLANTING		
Soil treatments	For grubs, Metarhizium and or Beauveria (Real IPM?)	**Dr. Rwegasira** to evaluate some of these products for insects of interest.
Mulching	Rice husks or straw	
Fertilizer	Beware of issues with high N; see 'curing' below.	
CROP ESTABLISHMENT		
Fertilizer	Beware of issues with high N; see 'curing' below.	
Sticky traps	for thrips	
Botanical pesticides	Neem or something else to repel thrips?	Need lit search for this.
Conservation biocontrol	Avoid broad spectrum insecticides (though this is not currently possible)	
Intercropping	With marigold, coriander? To repel thrips	
POST-HARVEST		
Curing	storage structures for air movement; standard procedures have been worked out for proper protocol.	
Curing	Fertilization affects post harvest quality: avoid high N even though farmers like large bulb; succulent growth makes it difficult to cure. High N also encourages growth and makes onion more susceptible to thrips.	

CROP: CABBAGE & OTHER BRASSICA CROPS

Main pests: Viruses, aphids, diamondback moth; Old-world bollworm Helicoverpa; whiteflies; cutworms, wireworm, black rot, soft rot, club root; weeds of many species; snails

	SPECIFIC PRACTICE	WORK NEEDED
PRE-SEASON PLANNING		
Crop rotation	to non-brassica crop for club root and nematodes; 2 seasons between brassicas are required to suppress club root.	
Variety selection	Resistant varieties: disease, Nematode-tolerant varieties available?	
Seed selection	Select healthy seeds	
PRE-PLANT ACTIVITIES		
Bed preparation	Raised beds in wet season, sunken beds in dry season.	
SEEDING		
Planting media (in plug	Pasteurized soil to suppress Pythium, seedling	

trays)	diseases	
	coconut dust to suppress Pythium, seedling diseases	
SEEDLING CARE		
Treatment of planting media after germination??	Trichoderma for club root, blackrot (?); & Bacillus subtilis?	
Seedling protection	Low tunnels;	
Insect exclusion	Netting for seedlings; agro-nets (?) to exclude whiteflies, aphids	
AT TRANSPLANTING		
Trap crops	Plant collards around perimeter of the field; treat with B.t. or other insecticide (needs to be tested here)	
Intercropping	with - marigold plants to repel insects	
CROP ESTABLISHMENT		
Insect exclusion	Use for seedlings; determine if practical for older plants, for aphid control.	
Mulching	Rice husks, or straw; plastic in some areas; to suppress weeds, conserve moisture	
pheromone traps	for DBM and Helicoverpa	
Microbial controls	Bt for DBM, Helicoverpa?	
Microbial controls	Bioslurry for insect pests; biogas byproduct. Use the solution of byproduct for spray for insects..	**Rwegarsira and Hellen;** Evaluate impact of biogas byproduct, adding Trichoderma, Bacillus in the process.
Botanical pesticides	Neem; pyrethrum/pyrethrins (with synergist PBO; might not be registered but should be investigated). Could import on trial basis).	
Conservation biocontrol	Avoid broad spectrum insecticides; esp where parasitoids present etc	
Irrigation	Overhead irrigation in evening to interrupt mating flights of DBM; might be a problem for disease.	needs evaluation by entomologist and pathologist. **Rwegasira**
POST-HARVEST		
	Many crops in brassica group; different issues for different crops.	
Sanitation	Destroy plant debris	

CROP: WATERMELON, CUCUMBER, & OTHER CUCURBITS

Main pests: Viruses; melonfly; **whiteflies**; bollworm; mildews (powdery, downy); botrytis; Weeds; red mites; **red spidermite**; nematodes; thrips; leaf miner; **aphids**; fruit rot;

Not agreement on ranking. Difference between geographic regions? Need survey to determine importance in different regions: Crop pest monitoring over 1-2 seasons.

Amon Maerere will oversee survey of pests over geographic areas and seasons.

	SPECIFIC PRACTICE	WORK NEEDED?
PRE-SEASON PLANNING		
Crop rotation	non-curcubit crops; one season; major crops often followed by curcubits.	
Variety selection	Virus resistant varieties available?; no resistance to major viruses of cucumber and watermelon.	
Seed selection	Select healthy seeds; most are purchased and treated with fungicides.	
PRE-PLANT ACTIVITIES		
Soil bed preparation	Raised beds to control drainage	

SEEDING		
Soil treatment	Pasteurized soil for Pythium	
Soil treatment	Trichoderma for pythium	
SEEDLING CARE		
	Low tunnels to avoid root problems for transplants; often direct seeding.	
Roguing	Virus infected plants; seedlings	
AT SEEDING OR TRANSPLANTING		
Soil treatment	Slurry with beneficial microbes e.g. Trichoderma.	**Delphina** will evaluate slurry with beneficials.
CROP ESTABLISHMENT		
Insect exclusion	Netting for whiteflies, aphids; remove at flowering to allow pollination	
Staking	trellis for cucumber	
Mulching	Rice husks or straw	
Sticky and pheromone traps	For whiteflies, melon flies; fruit flies	
Spider mite management	Augmentation with predatory mites	
Microbial controls	RealIPM products to test. Metarhizium ?	
Botanical pesticides	Neem	
Conservation biocontrol	Avoid broad spectrum insecticides	
Irrigation	Do not use overhead irrigation in evening	
POST-HARVEST		
Sanitation	Destroy plant debris	

CROP: BEANS *Phaseolus vulgaris*

Major Pests: Viruses, **bean stem maggot (BSM)**; aphids, thrips, whiteflies, Angular leafspot; common bacterial blight (CBB); bean anthracnose; bean rust; pod borer; flower sucking beetles (in northern zone); Nematodes; Many weeds.

BSM- esp in northern and southern highlands. Larvae in stem; stem rots, breaks. Need to check literature for possible parasitoids;

Dr. Rwegasira will review this literature and consider use of parasitoids for BSM.

	SPECIFIC PRACTICE	WORK NEEDED?
PRE-SEASON PLANNING		
	Crop rotation Non legumes; Needed for Pythium if drainage is not good.	
	Resistant varieties Some available for some diseases	
	Intercropping with maize, banana	
	Care for seeds Get seeds not harboring seedborne pathogens. Certified seeds available.	
PRE-PLANT ACTIVITIES		
SEEDING		
	Soil treatments Trichoderma Metarhizium seed treatment.	
SEEDLING CARE		
	Care for seeds Add rhizobium.	
CROP		

ESTABLISHMENT		
	Mulching for climbing beans; dry grasses animal bedding.	
	Staking especially for climbing varieties.	
	Sticky and pheromone traps for whiteflies	
	Conservation biocontrol: Avoid broad spectrum insecticides;	
	Microbial controls; RealIPM products to test.	
	Botanicals: Neem	
POST-HARVEST		
	Sanitation Destroy plant debris	

2 April: Depart for Addis Ababa;
3 April: travel to Hawassa, Ethiopia. We were met in Addis Ababa by Dr. Yibrah Beyene, who provided excellent commentary on the passing landscape and agriculture of the northern Rift Valley. We traveled about 275 km from Addis Ababa at 2400 m along a gentle slope to Hawassa at 1700 m. We passed llarge greenhouse operations for flower production and some vegetable production. Pesticide use is an environmental issue of growing concern. The vegetable industry is impacted by soil and water contamination. We were seeing a mostly dry landscape at the end of the dry season, though there were occasional natural and man-made lakes on either side of the wide valley. Entering the valley we passed strawberry production with row covers and possibly low-tunnels. The vegetable most common in fields at this time was onion. Thrips and purple blotch are significant problems; they are all hand-weeded. In the wet season one of the first crops will be potato. There are about 2 million hectares of crops in this region. Pests become aggressive and people attribute this to global warming. Main crops are vegetables, fruits, and coffee. Vegetables cover about 500,000 ha, most under irrigation: cabbage, tomato, onion, sometimes many varieties. There are plant health clinics that farmers can call on for pest and pesticide advice.

4 April: Hawassa University (30K students, about 1K in agriculture).
We met with Dr. Gashaw Meteke, Head, Plant and Horticultural Science School. He is a soil scientist with training from Oklahoma State University. His work involves GIS for drought monitoring. He explained their programs. They have 156 BS students, 74 MS students, and 22 PhD students with programs in Plant Science and Horticulture. They have recently added a biotechnology PhD program. Environmental horticulture is becoming more important with interest in urban greening. They are starting as a center of excellence; root crops are important including sweet potato, potato, and cassava. Vegetable crops in the area include onion (also shallots, garlic, leeks), cabbage "local" cabbage (*B. carinata*), tomato, chilies (green pepper is a new crop mostly for export), lettuce, watermelon, pumpkins; not African eggplant.

Group meeting attendees:
Ferdu Azerefegne, Leader, Entomologist, and co-PI, Yibrah Beyene, Entomologist, Alemayehu Chala, Plant Pathologist, Hiline Wolde, a lab assistant and possible graduate student candidate, Mark Erbaugh, R. Muniappan, John Cardina, George Norton, Celeste Welty.

Ferdu made an excellent presentation about vegetable production in the Rift Valley during which he prioritized crops and pests. Salient points from his presentation are as follows:
The Rift Valley is a large area that dissects the whole country. It holds intensive production of horticultural crops at different levels from small-holders to industrial scale farms. There is significant potential for intensification and expansion due to proximity and access to research and markets. It is also becoming a hotbed for pest problems, and for the widespread misuse and abuse of pesticides.

He presented survey data showing that 80 to 90% of farms grow onion or tomato, and 40-50% grow cabbage or chili pepper. Fewer than 10% grow potato, watermelon, beans, maize, sugarcane etc. Onion, tomato, cabbage and pepper are grown mostly in these areas: Meki, Koka, Ziway, Upper Awash, Gurage (Butajira), Hawassa zuria, and Arbaminch. Chilies are mostly grown in Gurage (Butajira) and Alaba; head cabbage in Kofele and surrounding areas. The types of farms range widely: Smallholders with little inputs, Small holders with high inputs, Contract farmers, Modern greenhouse and large scale farms. There is also a wide range in the level of knowledge and use of pest management. Small holders and contract growers are typified by year-round production with irrigation except, for chili which is rain-fed. They have open fields with furrow irrigation. They produce mainly for the local market, but some export to neighboring countries. Many are contract growers.

Farmers recognize the main pests and diseases. For example: Onion thrips, DBM; the growers know these. For control they depend mainly on pesticides. The main sources of information are pesticide dealers and fellow farmers. They use few pesticides but with high rates and frequencies. These are sprayed using manual knapsack sprayers and there is little awareness of pesticide safety or regulation in the use of pesticides. He described a typical "pesticide treadmill" wherein growers depend on a single pesticide when deemed effective, and switch to another when effectiveness lost. As effectiveness wears off they use higher doses and frequencies and mix several pesticides in an effort to get control. Pesticide application occurs when arthropod pests or their damage are observed, or at certain growth stage, e.g. fruit initiation for tomatoes and pepper against fruit worms. They generally wait for the appearance of disease symptoms and pay attention to cloudy and rainy periods. Many applications follow the crop calendar.

The table below was presented as a summary of the major pests of vegetables in this area.

Major pests on selected vegetables in the rift valley areas

crops	Arthropod pests	Diseases
Cabbage	Aphids, DBM, Thrips	Black head rot, fungal root rots
Onion	Thrips	Downey mildew, Purple blotch, Bulb rot
Pepper	Aphids, Thrips whiteflies ABW	EPMV and other Viruses, Powdery mildew, Bacterial spots, rots and wilts, Nematodes
Tomato	ABW, PTM, Tuta, Whiteflies, thrips Spider Mites	Late blight, Early blight Viruses, Leaf spots, Powdery mildew, Nematodes Fungal and bacterial wilts

Weed management in vegetables is largely by hand. A few farmers have started using herbicides on onions. They tested pendimethalin and, predictably, got good control of mostly grass weeds initially but effectiveness wore off after about 3 weeks. Shortage of labor and timely weeding are problems associated with hand weeding. But labor shortage is not a problem in some areas. Ferdu suggested: "The current project could introduce suitable and appropriate use of herbicides as an integral part of IPM in the vegetable production system of the rift valley of Ethiopia."

Ferdu indicated that the main areas for us to work are Koka, Meki and Ziway; Hawassa Zuria; and Butajira. These are all more or less between Addis Ababa and Hawassa. Partners in the project should include Hawssa and Ziway Plant Health clinics, Ministry of Agriculture, farmers, and private farms. There are bureaus of agriculture in each region with agronomist generalists.
The main IPM challenges identified are: Lack of observance of regulations by farmers, lack of a market incentive for IPM, studies mainly focused on individual problems and single methods, lack of integration of methods for pest management, and the strong attachment farmers now have to pesticides. He added that another challenge will be working with the clinics and farmers.

5 April: Hawassa University
In the morning we visited the Plant Health Clinic at Hawassa and discussed the project with experts there. In the afternoon we continued discussing specific IPM practices for individual crops and pests.

At the Plant Health Clinic: we met with Ato Germane Garuma Chagen, Deputy Bureau Head. He explained that there are three clinics in the region: the Hawassa clinic that oversees a half-million hectares of vegetables, fruits, and coffee; middle region with fruits (mango, banana), and a western clinic that deals with coffee and fruits. Pests move up the Rift Valley from the south. Cabbage, tomato, and onion are the main crops; there are 17 types of vegetables. Farmers call the clinic for advice or pring in samples for diagnosis. There are 67 districts for this one clinic (this is referred to as a warada). He clarified that requests for chemical use permits must go to the federal level, not the region. The structure is something like this: In the Region are 14 zones. There are 3 clinics in the region; there are 136 waradas in the region. The clinic in Hawassa has 67 warada, each warada has 15 – 78 kebeles, groups of 5 to 8 villages. Each zone has a crop protection expert, essentially an extension agent. Each kabele has a farmer training center with 1-3 ha of land, and ~5 experts. In each kabele are experts in plant science, animal science, forestry, vetinary science. These experts hoganize farmer teams; they also all have cell phones.
The crop protection regional expert is Sisay Lemawork. The Horticulture Crop Development and Protection Work Process Owner is Tefera Zenfu.
The phone system has a standard number: ATA8020 to call in about pest problems.
Teye Mamo is head of the clinic; MS in crop protection.
Germame Homsebo, M.S. plant pathology;
Alawi Shifa, M.S. weed science expert;
Getenesh Aragaw, B.S., Laboratory technician.

6 April: Hawassa
We met with Dr. Tesfaye Abebe, Vice President for Research and Technology Transfer at Hawassa University. He described efforts in community outreach, especially within 100 km of Hawassa. He described a participatory model and efforts to map out which problems are common for prioritizing education and health. He described lowland areas that are more tropical, mid-altitude areas like Hawassa, and high altitude areas. He spoke about "false banana" a perennial that is used against hunger, producing more dry matter than any cereal or root crop. He described technology transfer officers that do demonstrations at farmer training centers. They work with extension workers. They also write manuals, so far for cereal crops. Health extension works are working with women on improved nutrition. Vegetables are encouraged, especially kale, carrot, beet root, cabbage; these are produced mostly by women in backyard gardens.

The summary table of our discussion about IPM practices for priority pests on selected crops is on the next page

CROP: TOMATO

Main pests: Tuta, ABW – African Bollworm; PTM – Whiteflies; thrips; spider mites; nematodes; Late blight; early blight; viruses, bacterial spot; root rot;

	SPECIFIC PRACTICE	WORK NEEDED In Ethiopia
PRE-SEASON PLANNING		
Crop rotation	Non-solanaceous crop; staggered planting; maize	
Resistant varieties	Not resistant; buy seeds from outside, i.e imported, registered varieties; don't save seeds; mainly round	
Seed selection		
Host-free period		
PRE-PLANT ACTIVITIES		Lemayeyhu
Tillage	Not deep; soil is light; use ox plow. pH ~neutral.	
Soil bed preparation	Raised beds near rivers for seedlings. Sometimes same spot. Started burning on beds to "heat treat" but not tested.	This seems like an opportunity for improvement. Seedling production package. Sally; Alemaheyhu, Ferdu
	For planting, furrow.	
SEEDING	Barrier crop to intercept vectors, maize	
Seed treatment	None; whatever comes with seeds.	
Planting media (in plug trays)	Needs evaluation.	Needs evaluation Possible niche market
SEEDLING CARE		
Treatment of planting media??		Trichoderma – ID local strain; develop culture methods; Alemaheyhu
Seedling protection	Netting. But materials not available.	Need information.
Grafting	Bacterial wilt not enough of a problem.	Need survey.
Roguing	Always done.	
AT TRANSPLANTING		
Plug treatment	None	Interest in trichderma
Transplant treatment		
CROP ESTABLISHMENT		
Staking	90% for fresh market; paste type on the ground	

Mulching	Used for seedbed only; any grass competes with need for animal feed.	May investigate. Need a cost benefit and demo.
Sticky and pheromone traps	Not using now. Mass trapping with molasses – catches Tuta and everything	
Pruning	None	Removal of lower leaves could be studied.
Microbial controls	None	Need to investigate Metarhizium and Beauvaria; efficacy data; Ferdu will take care of policy; ; Yebrah & Ferdu to test products.
Botanical pesticides	None.	
Conservation biocontrol	None	
Irrigation	Furrow	
POST-HARVEST		
Fruit treatment	Sorting;	Investigate dip treatments
Sanitation	Destroy plant debris- need to do this for Tuta and diseases.	

CROP: ONION

Main pests: Thrips, purple blotch, downy mildew,

	SPECIFIC PRACTICE	Work needed in Ethiopia
PRE-SEASON PLANNING		
Crop rotation	Some areas plant onion after onion.	
Seed selection	Farmers produce seeds; no seeds treatment	
Variety selection	3-4 preferred varieties; onion sets, hybrids coming from outside, with claims of resistance;	
Delayed planting		
PRE-PLANT ACTIVITIES		
Tillage	Shallow tillage	
Bed preparation	Raised beds; broadcast seeds for transplant	
SEEDING		
Plug tray preparation		
SEEDLING CARE		
Insect protection	None; spray starts at this stage for cutworms etc	

Netting	None;	
AT TRANSPLANTING	Programmed spray, whether pest present or not	
Soil treatments		
Mulching		
Fertilizer	Organic fertilizers at seedling stage.	
CROP ESTABLISHMENT		
	Split application. High rates; goal is large bulb for high weight;	Need to verify
Sticky traps		
Conventional pesticides	High frequency 5-8; few insecticides; high dose; Investigate PERSUAP. Need to find out registered pesticides. See if PERSUAP is done for other crops. Can't use pesticides without PERSUAP, and N fertilizer from outside the country.	Need research on pesticide rotation of soft insecticides or mixtures; when to start, when to stop; test reduced frequency; maybe start with softer chemicals first; evaluate adjuvants to prolong and increase effectiveness; Ferdu as student working on pesticide rotation.
Herbicides	Have tested pendimethalin, but short residual and loss of effectiveness with soil disturbance; Hand weeding 3 times; Make sure PERSUAPs are available.	Experiment with one herbicide number of hand weedings; need to test postemergence herbicides; combine with stale seedbed. Yibrah
microbial pesticides		Need to evaluate Metarhizium for thrips; have been evaluating these.
Conservation biocontrol		
Intercropping		
POST-HARVEST		
Curing	No curing.	

CROP: CABBAGE & OTHER BRASSICA CROPS

Main pests: DBM; aphids; black rot; root rots; thrips,

	SPECIFIC PRACTICE	WORK NEEDED?
PRE-SEASON		

PLANNING		
Crop rotation	Non-brassica crop; in highland alternate with cereal	
Variety selection	Conventional varieties from Europe; marketability is main goal. Farmers have own preferences.	
Seed selection		
PRE-PLANT ACTIVITIES		
Bed preparation	Raised bed same as onion, tomato	Trichoderma to be evaluated
SEEDING		
Planting media (in plug trays)		Seedbed issues involve everyone.
SEEDLING CARE		
Treatment of planting media after germination??		
Seedling protection	Spray	
Insect exclusion	Netting	Needs to be tested
AT TRANSPLANTING		
Trap crops		
Netting		Needs to be tested
Intercropping		
ESTABLISHED CROP		
Insect exclusion		
Mulching		
pheromone traps		
Classical biocontrol	Diadegma for DBM	
Microbial controls		Test Bt for DBM; Not sure BT registered; Beauveria
Botanical pesticides		
Conventional pesticides	Contact and systemic insecticides; many applications; Aphids and DBM main target	
Irrigation		
POST-HARVEST		
		Incorporate brassica materials to reduce pests in next crop? Releases glucosinolates. Works when used with

		solarization; not sure in open.
Sanitation		

CROP: Chili/pepper

Main pests: Helicoverpa; ABW; aphids, thrips, whiteflies, viruses; powdery mildew.

	SPECIFIC PRACTICE	WORK NEEDED?
PRE-SEASON PLANNING		
Crop rotation	Other vegetable crop	
Variety selection		
Seed selection	Save seeds for chili; purchase pepper.	Evaluate seed treatments.
PRE-PLANT ACTIVITIES		
Soil bed preparation	Shallow tillage	
SEEDING		
Soil treatment	None	
Soil treatment		
SEEDLING CARE	Need to demonstrate netting; test low tunnels for seedlings; investigate materials for structure.	Small business opportunity to produce virus clean seedlings.
Roguing	Yes.	
AT SEEDING OR TRANSPLANTING		
Soil treatment		
ESTABLISHED CROP		
Insect exclusion		
Staking		
Mulching		
Sticky and pheromone traps		
Spider mite management		
Microbial controls		Test trichoderma, other microbials.
Botanical pesticides		
Conservation biocontrol		
Irrigation		
POST-HARVEST		
Sanitation		

7 April: Return to USA.

Summary Suggestions, Recommendations, and/or Follow-up Items:

In all countries, we emphasized the need for participants to complete a project work plan for the first two years. Funding will only be available for participants who complete these project plans.

We discussed the baseline survey that George Norton will lead in conjunction with Dr. Beth Ndungu, Gender expert in Kenya, Mark Erbaugh (OSU), and Cathy Rakowski (OSU). The goal in each country is to get a baseline farmer survey of about 400 participants per country. Gender questions will be included on the survey. George will work with the social scientists and others to make sure this is conducted properly. Site, sample and interviewer selection and training will need to be pursued in regional training meeting.

In all countries there was a consensus that doing 6 vegetable crops is unreasonable given the small budget available. Three crops were prioritized in each country.

It was also apparent to all participants that due to the delay in starting the project, the first year work will mainly be in the survey and lab or on-station trials to test individual technologies. In all 3 countries and with most of the priority crops it was indicated that farmers relied on pesticides as the main form of pest control. IPM packages and subsequent field-trials and farmer trainings should focus on reducing pesticide applications.

The tables that were prepared for each country represent a draft IPM package that contains components that need to be tested. The tables should serve as a document to guide the work of the project. Not all activities can be pursued. Each site will need to prioritize pests and follow-up research.

In Kenya the initial interest appears to be on testing biocontrols and microbials, many of which are available from RealIPM.

In Tanzania the initial interest appears to be diverse, and includes: evaluation of grafting on wild solanum rootstock; recipes for slurry and microbes (e.g. Trichoderma etc); evaluation of onion varieties, hybrids for virus resistance; a time of planting study to look for time impact on disease and insect pests; evaluation of bio products for insects; a literature search for biopesticides to repel thrips; use of a biogas byproduct, adding Trichoderma, Bacillus in the process.

In Ethiopia there is a great opportunity to make an impact by testing and demonstrating methods to improve seedling production. This would be an opportunity to support entrepreneurial work to produce disease- and insect-free seedlings for farmers.

In all three countries, insect-vectored viruses appear to be a significant challenge. More research and outreach efforts are clearly needed in this area to reduce wasted ineffective pesticide sprays and to protect seedlings in an effort to at least delay infection. Cooperation between virologists and entomologists will be essential in this effort.

List of Contacts Made:

Name	Title/Organization	Contact Info
Tesfaye Abebe	VP for Research and Tech Transfer, Hawassa University	tesfayea@hu.edu.et
Ferdu Azerefegne	Hawassa University, Ethiopia	azerefegnef@yahoo.com fazerefegne@hotmail.com
Yibrah Beyene	Hawassa University, Ethiopia	Yibrah_beyene@yahoo.com yibrahb@hu.edu.et
Thomas H. Carr	NAFAKA, Tanzania	tcarr@nafaka.tz.org +255 22 2700042
Anthony P. Chamanga	TAHA, Tanzania	anthony.chamanga@taha.or.tz
Charity Gathambiri	KALRO, - Post harvest	
Caeser Kambo	KALRO- Entomologist	
Brhane Gebrekidan	Virginia Tech	bgebrekidan@gmail.com
Hellen Kanyagha	SUA	hmbye@yahoo.com
Sylvia Kuria - Pathologist	KALRO	
Amon Maerere	SUA	maerere@suanet.ac.tz; +255 776 363 202
Delphina P. Mamiro	SUA	Mamirodelphi@gmail.com
Christopher L. Materu	MARI – entomologist	chrismateru@yahoo.com
Jesca Mbaka	KALRO	jnmbaka@yahoo.com +254 722882422
Hosea D. Mtui	SUA	mtuihosea@yahoo.com
Mulinge Mukumbu	Deputy Director, Kenya Agric Value Chain Enterprises KAVES	mmukumbu@fintrac.com +254 715 818 996
Charles Waturu Nderito	Director, Horticulture Research Institute, KALRO	Charles.waturu@kalro.org Director.hri@kalro.org
Joseph Ndunguru	MARI, Tanzania	jndunguru2003@yahoo.co.uk
Dr Beth Ndungu - Gender expert	KALRO	
George A. Odingo	Technical Director, KAVES	godingo@fintrac.com +254 738 900 005
Gration M. Rwegasira	SUA	grwegasira@suanet.ac.tz
Peter Sseruwagi	MARI, Tanzania	psseruwagi@yahoo.co.uk
Juma Shekidele	Horticultural Research and Training Institute, Tanzania	jsheiza@yahoo.co.uk
Tadele Tefera	ICIPE-Ethiopia	ttefera@icipe.org
Henry Wainwright	Real IPM, Kenya	wainwright@realipm.com
Lusike Wasilwa	Director, Crop Systems, KALRO	lwasilwa@gmail.com Lusike.wasilwa@kalro.org
Helina Weldie	Hawassa University	helinawe@gmail.com