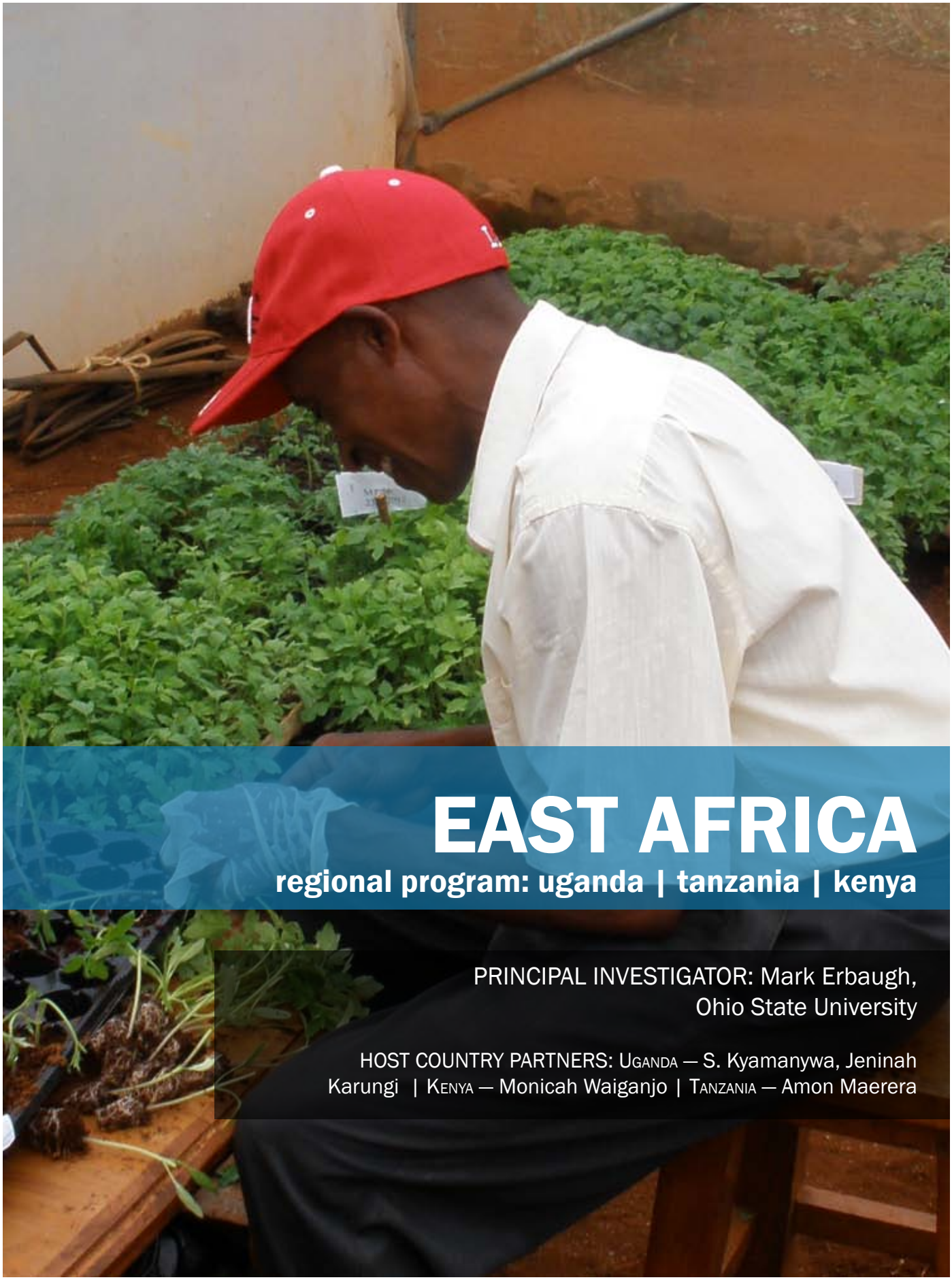


EAST AFRICA

regional program: uganda | tanzania | kenya

PRINCIPAL INVESTIGATOR: Mark Erbaugh, Ohio State University

HOST COUNTRY PARTNERS: Uganda — S. Kyamanywa, Jeninah Karungi | Kenya — Monicah Waiganjo | Tanzania — Amon Maerera

East Africa

program summary

In Uganda, the registration and release of the tomato variety MT56, which is resistant to bacterial wilt, has been undertaken. Grafting scions of desired varieties of tomato on bacterial wilt resistant MT56 rootstock has become popular with farmers in bacterial wilt infected areas. Field trials are being conducted for management of boll worm, leafminer, mites and diseases of tomato. *Tomato mosaic virus, tobacco mosaic virus, Cucumber mosaic virus* and *Tomato spotted wilt virus* were found on tomato. Experiments are being conducted to evaluate the resistance of KP4, a local passion fruit cultivar, to collar rot disease. Coffee root mealybug and white stem borer are problems in Arabica coffee. Pheromone traps are being tested for coffee twig borer control.

In Kenya, grafting technology has been introduced to overcome bacterial wilt disease of tomato in the open fields as well as in high tunnels. Soil solarization was also found to reduce incidence of bacterial wilt. Passion fruit virus disease detection technology has been validated. Population dynamics of thrips in onion fields has been studied.

In Tanzania, impact of management practices on postharvest physiology and shelf line of tomato was studied. Trials are being conducted for management of white coffee stem borer, Antestia bug, coffee berry borer, and coffee berry disease. Trials are being conducted for management of *Thrips tabaci*, a major pest of onions.

UGANDA

Tomato

IPM package transfer to tomato farming communities

Jeninah Karungi, Zachary Muwanga, G. Biiso, Samuel Kyamanywa, Sally Miller, and Mark Erbaugh

The purpose of this activity was to disseminate the tomato IPM package developed during previous years to the Kirimagondo farmers' field school (KFFS) group in Kamila Sub County, Luwero district using a modified farmer field schools (FFS) approach. The IPM package being disseminated consisted of nursery management practices (soil sterilization), a variety with resistance to bacterial wilt (MT 56), and mulching, ridging, and staking, aimed at reducing pesticide (fungicide/insecticide) usage and easing field activities. The Kamila Sub County extension agent was the facilitator of the FFS and was responsible for the fortnightly training of farmers. KFFS has a membership of 25 farmers (12 men, 13 women). The trainings imparted skills/techniques for integrated pest management following the crop's growth cycle.

Registration and release of tomato variety MT 56 to the Ugandan farming community

Patrick Rubaihayo, Sam Kyamanywa, Jeninah Karungi, Didas Asiimwe(RIP), Jackie Bonabana-Wabbi, Matt Kleinhenz, Sally Miller, and Mark Erbaugh

The purpose of this activity was to complete the registration of MT56 in Uganda. All the documents and verifications needed by the Ugandan National Varietal Release Committee have been submitted, including the validation of performance in different seasons and different agroecological zones and the compilation of genetic background and variety description. These results have been reported in previous annual reports. Currently we are waiting on communication from the committee.

Integrated pest management of *Ralstonia solanacearum* on tomato in Uganda

Jeninah Karungi, Geoffrey Tusiime, Patrick Rubaihayo, Robinah Ssonko, Didas Asiimwe, Samauel Kyamanywa, Sally Miller, and J.M. Erbaugh

MT56, a tomato variety introduced to Uganda from the Ohio Agricultural Research and Development (OARDC) Breeding Program, had been observed to be moderately resistant to *Ralstonia solanacearum* in the country. Current research has aimed at confirming the resistance of the variety and exploring the efficacy of other cultural practices as a robust integrated management strategy for this priority tomato disease. In one study, eight tomato varieties — CLN3022D, CLN3022F, CLN3024A, CLN2418 (from AVRDC); Tengeru- 97, Moneymaker, Marglobe and Roma (commercial varieties in Uganda); and MT56 — were inoculated with *R. solanacearum* at a population of 1×108cfu ml-1 in a complete randomized design with five replications to record disease development on potted plants. *R. solanacearum* symptoms were apparent 10 days after inoculation (DAI) and developed differently across genotypes. MT56, CLN3024A, CLN24118A, and CLN3022D had the lowest disease incidence.

Another study assessed the potential of grafting as a strategy for managing *R. solanacearum* on tomato. Five treatments were studied in a randomized complete block design: i) Onyx, a bacterial wilt susceptible commercial variety grafted on *Solanum complycanthum* (Kitengotengo), ii) Onyx grafted on *Solanum indicum* (Katunkuma), iii) Onyx grafted onto *Solanum* sp. (Katengotengo), iv) Onyx, ungrafted as a check, and v) un-grafted MT 56 as a second check. Results indicated that grafting on different root stocks varyingly reduced the incidence of *R. solanacearum* on tomatoes as well as fruit yield. Another trial assessed the effect of integrating MT56 with previously tested cultural practices of mulching with straw and staking with wooden sticks vs. the untreated tomato plants in a randomized complete block design with three replications. Results indicated that mulched/staked plants had lower *R. solanacearum* incidences than untreated plants. The tactics used in the different trials that provided consistently good results have now been transferred to farmers where they have been widely adopted. Plans to release MT56 on the Ugandan market have been initiated.

Develop and promote techniques for management of boll worm, spider mites, leaf mining flies, and key diseases on tomato

Michael Otim; Samuel Kyamanywa, Zachary Muwanga (MSc student), Innocent Tumwesigye, Matt Kleinhenz, & Joeseph Kovach

The purpose of this activity was to use mulches and well-timed pesticide applications to reduce pesticide applications from 12–24 per season to 2–3 and to manage insect pests/diseases. The experiment used a completely randomized block design (CRBD) with seven treatments replicated four times. The treatments were: (T1) spraying once every week with a mixture of Dimethoate and Agrolaxyl chemicals to control both insect pests and disease; (T2) spraying the mixture once at vegetative growth and once during flowering; (T3) spraying the mixture twice during flowering and twice during fruiting; (T4) weekly application of Agrolaxyl fungicide sprays only; (T5) weekly application of Dimethoate insecticide only; (T6) untreated / mulched; and (T7) untreated / unmulched.

Preliminary results on fruit yield and cost-effectiveness of the different spray schedules indicate that mulching alone caused a yield gain of 534kg/ha (1 and 2). The most profitable spray schedule was two sprays of the mixture of a fungicide and insecticide, once in vegetative and flowering stages, respectively (tabs. 1 and 2).

Distribution and characterization of major viruses infecting tomato in Uganda

Mildred Ochwo-Ssemakula, Peter Sseruwagi, Warren Arinaitwe, Feng Qu, Sally Miller

Virus disease surveys were conducted to assess the incidence and severity of viral diseases in tomato fields in eight major growing districts of Kasese, Mbarara, Mpigi, Luwero, Ntungamo, Rukungiri, Kamuli, and Mbale for two consecutive seasons. In addition, infected leaf samples were collected for further serological identification. A total of 71 tomato fields were scored for

virus disease incidence and symptom severity. A collection of 127 leaf samples were tested using ELISA for *Tomato mosaic virus* (ToMV), *Tobacco mosaic virus* (TMV), *Cucumber mosaic virus* (CMV), *Tomato spotted wilt virus* (TSWV), and potyviruses, and all were confirmed present in most surveyed fields using ELISA. On average, in the first season ToMV had the highest incidence (33%) and TSWV, the lowest incidence (2%), while in the second season, CMV had the highest incidence (60%), and TSWV, the lowest incidence (8%).

Effect of plastic mulch and soil amendments on occurrence of tomato viral diseases and their vectors in Uganda

Jeninah Karungi, Samuel Kyamanywa, Mildred Ochwo-Ssemakula, Peter Sseruwagi, Matt Kleinhenz, Joseph Kovach, Mark Erbaugh, Chris Muwanika (MSc. Student)

The purpose of this activity was to establish the influence of plastic mulch and soil amendments on the occurrence of tomato viral diseases and their insect vectors. Over two consecutive seasons and on-station at MUARIK, the effect of five treatments on the occurrence of insect vectors, natural enemies, viral infections, and tomato yield were evaluated. The treatments were: i) plastic mulch, ii) cattle manure, iii) straw mulch, iv) coffee husks, and v) untreated control. Preliminary results indicate that the incidence and severity of tomato virus diseases, some of the insect vectors, and natural enemies varied significantly ($P<0.05$) across seasons and among the treatments. Using molecular analysis (PCR), *Tomato yellow leaf curl virus* (TYLCV) was detected in all leaf samples tested.

Passion fruit

Efficacy of grafting, cultural practices, and biological control in the management of key diseases of passion fruit

Mildred Ochwo-Ssemakula, Peter Sseruwagi, Jeninah Karungi, Samuel Kyamanywa, Sally Miller, Mark Erbaugh

The purpose of this activity was to evaluate the resistance of KP4, local yellow, purple, and sweet calabash passion fruit cultivars/lines for resistance to collar rot disease. Soil samples were obtained from fields of passion fruit plants showing collar rot disease symptoms in the main passion fruit producing districts of Uganda, Mbale, Mubende, Lira, Tororo, Nakasongola, and Mukono districts. The pathogen was isolated and cultured on PDA medium in microbiology Laboratory at Makerere University. Pure cultures of *Fusarium solani* were then incorporated into millet grains carrier medium for use in host resistance evaluation. A screen house trial to screen the above mentioned passion fruit germplasm against the isolated *F. solani* is currently running at MUARIK. Eight seedlings of each cultivar were inoculated with a specified dosage of the *F. solani* isolate. Controls were passion fruit seedlings of each variety grown in sterilised soil.

Preliminary observations indicate that symptom expression, including diebacks, leaf yellowing, and intervein necrosis, are varying according to specific cultivars (figs. 1 and 2).

Table 1. Mean weight of marketable tomatoes between treatments and at subsequent harvests

Mean marketable weight (kg/ha) for different treatment and time						
	Harvesting					
Treatment	**1**	**2**	**3**	**4**	**5**	**Mean**
T1	713	1152	672	1712	2462	1343
T2	190	1122	465	2350	2072	1240
T3	770	1505	668	1825	1540	1261
T4	968	558	580	1250	1775	1026
T5	522	798	462	2122	1597	1100
T6	732	708	600	1512	1487	1008
T7	465	432	352	460	657	474

Table 2. Mean yields of marketable tomatoes and marginal returns for the different pesticide spray schedules

	Harvesting				
Treatment	**Yield Kg/ha**	**Yield gain over control Kg/ha**	**Gross returns (UgX/ha)**	**Cost of sprays (UgX/ha)**	**Net returns (UgX/ha)**
T1	1343	869	1,738,000	1,252,571	485,429
T2	1240	766	1,532,000	313,143	1,218,857
T3	1261	787	1,574,000	776,286	797,714
T4	1026	552	1,104,000	1,200,000	-960,000
T5	1100	626	1,252,000	52,571	1,199,429
T6	1008	534	1,068,000	_	_
T7	474	_	948,000	_	_
L.S.D	529.9	_	_	_	_

*Market price of tomatoes was 2000/per kilogram; in calculating net returns, other input costs were kept constant apart from costs associated with pesticide (chemical) usage.

Figure 1. Dieback symptoms on the passion fruit plant

Figure 2. Leaf defoliation symptoms on a passion fruit plant

Integration of cultural practices for management of insect vectors and associated viral diseases of passion fruit

Michael Otim, Mildred Ochwo-Ssemakula, Peter Sseruwagi, Geoffrey Tusiime, Robinah Atukunda (MSc student), Sally Miller, and Joe Kovach

To understand the production environment of smallholder passion fruit production systems and farmers' perceptions of viral diseases of passion fruit in Uganda, a survey was conducted in Buyikwe and Mubende districts (viral disease hot spots) in Central Uganda. Interviews were conducted in 60 households of passion fruit farmers. The overall ratio of male to female respondents was 9:1 with more males (90%) than females (10%). A majority of the respondents had formal education, with 43%, 25%, and 8% having attained primary, secondary and post-secondary levels respectively. 23.3% had no formal education. Farming was the main occupation of the respondents (86%), with the rest engaged in other businesses, and only 1.7% were employed formerly. Farms were characterized by small holdings, with the majority (60%) ranging from 0 to 5 acres. Only 14.4% had farm holdings greater than 15.1 acres. Biotic factors including diseases and pests were the biggest constraints faced by farmers, with viral infections in particular ranked the highest.

The purpose of this task was to identify alternative hosts for passion fruit aphid vectors and associated potyviruses. Aphids that vector passion fruit viruses have a wide host range including weeds and other crops growing within the vicinity of passion fruit plants. During the survey, aphids and plant species showing virus-like symptoms found in the vicinity of passion fruit in farmers' fields were collected to assess their potential as vectors or alternate hosts respectively. PCR and RT-PCR laboratory analysis of the aphid insects and plant species is on-going at NARL- Kawanda. The sampled aphid species were identified using a digital microscope and identification keys. A list of probable alternative hosts was generated but will be confirmed only after laboratory analysis. In all, 40 aphid samples were collected, from which 4 aphid species have been confirmed (tab. 3).

Coffee

Establishing action thresholds for insect pests of Arabica coffee in the Mt. Elgon Zone

Samuel Kyamanywa, Jeninah Karungi, Charles Ssemwogerere (MSc student), Patrick Kucel, Joseph Kovach

Action thresholds are diagnostic tools that assist in determining when to apply corrective interventions and are part of overall IPM package. The field work t**o e**stablish action thresholds and economic injury levels of key insect pests and to validate these on-farm has just been completed, and data has been entered. Results show that all treatments had a significant ($P<0.05$) effect on the mean pest incidence for stem borers, canopy scales and mealybugs, leaf miners, skeletonizers, and caterpillar damage. However, treatments were not significant ($P>0.05$) for mean pest incidence for Antestia bugs, root mealybugs, lace bugs, and coffee berry borer. As with the first season data, pesticide treatments had little effect on mealybugs, scales, and the coffee berry borer. Antestia bugs and the white stem borer responded to pesticide treatment. Foliar sprays were found to be more efficient in reducing pest populations than soil applications.

IPM of the white stem borer and root mealybugs on Arabica coffee in the Mt Elgon region in Uganda

Samuel Kyamanywa, Patrick Kucel, George Kagezi; K. Nafuna, Charles Ssemwogerere, Mark Erbaugh, and Joseph. Kovach

Major pests of arabica coffee in the Mt. Elgon region are *Planococccus irenues* and *Bixadus sierricola* at both high and low altitude. Management options against the pests were developed and evaluated including stem smoothing and wrapping. These were found to consistently reduce the incidence of *B. sierricola* (by 37.4% and 31.2%, respectively). Enhancement of soil fertility through application of a commercial fertilizer (CAN), animal manure, or intercropping with beans was found to reduce *P. irenues* damage (by 62.2%, 48.1%, and 22.2%, respectively). These management options were validated on-farm during the 2009-2010 period, after which efforts were focused on disseminating the technologies to coffee farming communities. A farmers field school (FFS) approach was used to disseminate these management practices in Sironko district, Buwasa Sub County. The FFS has a membership of 63 farmers (40 males and 23 females). Regular sessions of the FFS have been implemented, and farmers are in agreement that the technologies are effective and have reduced losses in the short term. However, they noted that stem wrapping was not very practical because termites destroy the banana fiber wraps as soon as they are applied, necessitating frequent re-wrapping. Plans for up-scaling the technology to more sub counties are underway.

Effect of pruning, stumping, and burning in managing the coffee twig borer (CTB) and coffee wilt disease

Samuel Kyamanywa; Patrick Kucel, George Kagezi, Joseph Kovach

Community-based phyto-sanitary BCTB management trials were implemented through Twekembe Coffee Farmers Field School (Ntenjeru sub-county, Mukono district) and Kezimbira Coffee Farmers' Field School (Nakaseke T.C., Nakaseke district) to implement phytosanitary interventions for BCTB control that included desuckering, pruning and burning of infested coffee plant parts, and elimination of alternate host plants. The CTB scores and other plant parameters on phytosanitary farms were compared with the non-phytosanitary ones in order to establish the efficacies of the approach.

Table 3: Aphid species identified and the host plants on which they were found

Common name	Scientific name	Host plant (Where the aphid was found)
Green peach aphid	*Myzus persicae*	*Capscicum annum* (Green pepper)
Cotton/ Melon aphid	*Aphis gossypii*	*Bidens pilosa* (Black jack)
Sowthistle aphid	*Hyperomyzus lactucae*	*Sonchus oleraceus* (Sowthistle)
Bean aphid	*Aphis fabae*	*Phaseolus vulgaris* (Bean)

Figure 3. Modified CTB trap made up of a perforated mineral water bottle and a McCarthney vial dispenser inside

A participatory alternate host search conducted within the FFS has so far reported 30 plant species, belonging to 17 families, as potential plant hosts for the CTB. These will be confirmed through in-vitro tests.

In another study, ethanol and methylated spirits were used in improvised traps on-station to trap CTB as a control measure. These trials focused on the development of protocols based on trap modifications, selection of attractants, and trap placement methods. A modified trap has been adopted using a combination of ethanol and methanol (fig. 3). McChartney vials have been adopted as dispensers of the attractants in the modified traps. Preliminary trappings using the ethanol and methanol combinations consisted of CTB, CBB, and an assortment of coleopteran and lepidopteran insects. New attractants such as ETOH, ETOH-PHERO, and Eugenol are currently being evaluated before a final shortlist of attractants is generated for field mass CTB trapping evaluation trials.

The effect of conventional vs. IPM management system on priority pests

Samuel Kyamanywa, Patrick Kucel, George Kagezi, Joe Kovach, Mark Erbaugh

The Kimbowa United Coffee Farmers' group was initiated in 2011 to upscale and outscale new IPM technologies developed by IPM CRSP research for the control of stem borers and root mealybugs. From an initial membership of 21 coffee farmers mainly from the villages in Sironko district, the school has now expanded to 64 members. The outscaling of the technologies was to be achieved through the FFS approach to technology generation and dissemination. A FFS field day was conducted on the farm of Mr. Patrick Namoma on 12 May 2012. The attendance was 42 members (28 males and 14 females). The main activities of the field day were to listen to farmers discuss and describe IPM technologies they had viewed and to train farmers on gender issues in coffee production and record keeping. Both male and female farmers were able to remember and demonstrate aspects of the disseminated technologies including stem smoothening, stem wrapping, de-suckering, and pruning and explain the reason each was done.

After the FFS session, the team visited the coffee plantations of two members of the FFS, Mr. Charles Masolo and Mr. Woganala Peter, to assess adoption of technologies disseminated through the FFS. Both farmers were found to have tremendously improved in their coffee management compared to their neighbors who are non-members of the FFS.

Hot pepper

Training of extension workers on diagnosis of pests of key horticultural crops

Mildred Ochwo-Ssemakula, Jeninah Karungi, Samuel Kyamanywa, Herbert Talwana, S.B. Mukasa, Warren Arinaitwe, M. Nantale; P. Kucel, NARO; R. Karyeija, A. Mugalula, J. Okee, MAAIF; J. Kovach, S. Miller, M. Erbaugh, OSU

The Government of Uganda is scaling out plant clinics to its decentralized districts under the Development Strategy and Investment Plan (DSIP) in order to facilitate its Crop Protection function. The Makerere University Plant Diagnostics Laboratory, established with funding from AFSI under the umbrella of IPM CRSP, was identified as a reference laboratory for the Plant Health Systems in Uganda. The laboratory will provide technical backstopping by diagnosing samples referred from the National Phytosanitary Facility in Namalere, Uganda. These plant clinics are to be managed by district staff at the sub-counties, who include extension agents and agricultural officers. Makerere University was invited to collaborate by providing technical backstopping that falls under its training and outreach mandates. Through the Regional IPM CRSP and its global theme on plant diagnostics (IPDN), training was provided to plant doctors in nine districts that included: Buyikwe, Kayunga and Mukono in Central Uganda; Hoima, Kibaale, Masindi, Kasese and Bundibugyo in Western Uganda and Mbale in Eastern Uganda. Three training sessions were organized using workshops with practical field excursions to reinforce learning. Workshop themes were selected to target the technical strengths of IPM CRSP and Makerere in line with the needs identified by the districts.

KENYA

Tomato

On farm grafting trials at Kirinyaga to compare the effects of grafting and high-tunnel tomato production on pest incidence

Monicah Waiganjo, C. Kambo, Sylvia Kuria, C. Njeru, J. Mbaka, Daniel Gikaara, Ruth Amata, Mark Erbaugh, Sally Miller, Samuel Kyamanywa, Matt Kleinhenz, Joseph Kovach, C. Gathambiri, S. Wepukhulu

A third season on-farm high tunnel and open field tomato grafting trial was carried out in Mwea, Kirinyaga County in collaboration with Bayer tomato farmers from October 2011-March 2012. Grafted and ungrafted seedlings were transplanted after one month of sowing using the recommended 30 x 60 cm spacing for tomato production, in a two factor randomized complete block replicated four times in each of the two systems (open field, high tunnel). Similar fertilizer application, pruning, weeding, irrigation, and other agronomic practices were carried out by the farmer group in both the high tunnel and open field. The high tunnel used in this on farm trial had a width and length of 8 m and 15 m respectively, an exclusion-double door, and a foot bath to ensure disinfection into the high tunnel, while the sides were made of 50 mesh insect proof netting. Arthropod pest population was recorded fortnightly from five randomly selected tomato plants per plot. Insect populations were estimated by 0-5 score representing no infestation (0), slight (1), mild (2), moderate (3), high (4), and severe (5) for whiteflies and aphids. Insect counts on thrips (adults and larvae) were recorded from five plants per plot. Bacterial wilt incidence was assessed by examining all the plants in each plot for the presence or absence of the disease. The number of infected plants per plot was recorded, and the percent disease incidence was calculated in each treatment in the two production systems (high tunnel and open field). Tomato weight was taken by harvesting from all plants per plot and yield calculated for each treatment on hectare basis.

The major pests observed in the tomato crop in both seasons were whiteflies, (*Bemisia tabaci*), thrips, (*Frankliniella occidentalis* and *F. Schultzei*), and aphids, (*Aphis gossypii)* (tab. 4). Significantly higher infestation by all the pests occurred in the open field than in the high tunnel. In the open field, the tomato crops were moderately to highly infested with whiteflies (3.46 -4.02) and slightly infested with aphids (1.11-1.36), while the mean thrips numbers ranged from 5-8/plant. There was no significant difference in pest populations between the grafted and ungrafted tomato in both systems (tab. 4).

Among the ungrafted tomato, bacterial wilt severely infected both determinate and indeterminate tomatoes grown in the two production systems (tab. 5). However, grafting the bacterial wilt susceptible variety Onyx on resistant Mt56 resulted in significantly less disease incidence among the tomato in both high tunnel (15%) and open field (25%). Near total crop loss (90% and 88.7%) occurred in the ungrafted Onyx in open field and high tunnel, respectively. The indeterminate variety Anna F1 was less susceptible to wilt compared to ungrafted Onyx, but the difference was not significant at p=0.05. The grafted tomato (Onyx) recorded significantly least percent bacterial wilt incidence (25.45% and 15.00%) in the open field and high tunnel respectively. No significant difference in the disease incidence occurred between the open field and high tunnel production systems.

Table 4. Effects of high tunnel and grafting on tomato arthropod pests incidence

Production system	Tomato plants	Whiteflies	Thrips	Aphids
Open field	Onyx	4.02±0.19a	8.03±3.09a	1.11±0.01a
	Grafted Onyx	3.57±0.19a	6.05±3.08a	1.24±0.01a
	Anna F1	3.46±0.19a	5.18±5.08a	1.36±0.01a
High tunnel	Onyx	0.11±0.01b	1.14±0.03ab	0.0b
	Grafted Onyx	0.0b	1.01±0.03ab	0.0b
	Anna F1	0.0b	0.0b	0.0b
P		<0.001	0.012	<0.001
C.V		23.5	44.7	15.8

Within a column, means marked with the same small letter are not significantly different by Student Newman's Keuls (SNK) test @ p=0.05.

Table 5. The effect of grafting on percent tomato wilt incidence± s.e.

Production system	Onyx	Grafted Onyx	AnnaF1	P- value
Open field	90.05 ±5.31aA	25.45 ±0.06aB	74.35±2.6aA	0.0013
High tunnel	88.7±0.05aA	15.00±0.00aB	56.02±0.08aAB	<0.0001
P-value	0.256	0.134	<0.001	
% C.V	29.8	43.6	25.2	

Within a column, means marked with the same small letter are not significantly different while means marked with the same capital letter within a row are not significantly different by SNK @ p=0.05

Table 6. Effects of high tunnel tomato production and grafting on tomato yield (ton/ha)

Production system	Onyx	Grafted Onyx	AnnaF1	P- value
Open field	1.39±0.55aC	10.67±1.05aB	19.21±0.68bA	<0.0001
High tunnel	2.15±3.06aC	15.4±2.9aB	26.82±2.51aA	<0.0001
P-value	0.0651	0.027	0.0024	
% C.V	45.2	34.8	28.6	

Within a column, means marked with the same small letter are not significantly different, while means marked with the same capital letter within a row are not significantly different by SNK @ p=0.05

There were significant differences in yields between the tomato varieties and the production systems (tab. 6). Yield assessment of the marketable tomato showed that var. Ann F1 hybrid which is an open pollinated, indeterminate variety had significantly higher ($p<0.0001$) yield in both open field and high tunnel systems than the determinate grafted and un-grafted Onyx.

- The use of high tunnel with insect proof netting and double doors reduced pest entry and consequent crop infestation. It greatly reduced the use of pesticides compared to the open field, resulting in higher food safety.
- High tunnels have a key role for small farms in reducing the need for pesticides.
- Grafting had significant increase on yields in both production systems. However, grafting had no significant effect on the arthropod pest incidence.

Evaluation of soil solarization in management of bacterial wilt in high tunnel tomato production

Monicah Waiganjo, C. Kambo, Sylvia Kuria, C. Njeru, J. Mbaka, Daniel Gikaara, Ruth Amata, Mark Erbaugh, Sally Miller, Samuel Kyamanywa, Matt Kleinhenz, Joseph Kovach, C. Gathambiri, S. Wepukhulu

Three soil treatments for the management of bacterial wilt in high tunnel-grown tomatoes were tested. These included (1) complete coverage solarization for 8 weeks; (2) strip solarization for 3 weeks (normal practice by majority of farmers); and (3) excavation of infected soil and replacement with imported forest soil. Tomato seedlings (var. Tylka Hybrid) were transplanted into all the beds. The crop was watered by drip irrigation, using water-guard (sodium hypochloride) treated water to minimize chances of bacterial wilt infection from irrigation water. Data was collected on the number of plants showing symptoms of bacterial wilt between transplanting and first harvest

Strip solarization for three weeks did not appear to offer any control of bacterial wilt, as the crop was wiped out even before reaching maturity. Complete coverage solarization for eight weeks had the lowest bacterial wilt infection compared to both strip coverage for three weeks and infected soil replacement treatments (figure 4). After 6 weeks plots, completely covered with plastic had 21.4% wilt incidence, while uncovered plots had 51.8% wilt incidence. The practice of replacing infected soil with seemingly uninfected forest soil did not reduce bacterial wilt significantly. This is probably because it is difficult to effectively replace all the infected soil and prevent contamination.

- It is therefore recommended that high tunnel tomato farmers in Kangai and surrounding areas (which are hotspots of bacterial wilt) should practice complete coverage solarization for at least 8 weeks.
- Although bacterial wilt infection was not completely eliminated in our trial by complete coverage solarization for 8 weeks, the results are very promising. With more adaptation of the solarization method, it is possible to reduce the bacterial wilt infection to negligible levels.

Table 7. Effects of soil solarization on the yield and tomato productivity at Kangai-Tisa, Kirinyaga, Kenya

Treatments	No. plants	No of plants surviving	Yield (kg)	Av. price/ kg (USD)	Gross Income (USD)
8 weeks complete cover solarization	40	32	250	0.5	125
3 weeks strip solarization	40	0	0	0.5	0
Soil replacement	40	4	5	0.5	2.5

Figure 4.Healthy tomato plants in solarized soil and dead plants in non-solarized soil

On-farm grafting trials at Kangai Tisa using new commercial tomato scions and wilt tolerant rootstock (Mt56, cherry tomato, *Solanum incanum*, and TKA-193-31)

Monicah Waiganjo, C. Kambo, Sylvia Kuria, C. Njeru, J. Mbaka, Daniel Gikaara, Ruth Amata, Mark Erbaugh, Sally Miller, Samuel Kyamanywa, Matt Kleinhenz, Joseph Kovach, C. Gathambiri, S. Wepukhulu

The trial is a participatory research activity with Kangai Tisa farmers group. The seedlings were transplanted on August 9, 2012, in a split-plot design with two main plots and ten sub-plots. The main plots included high tunnels whose beds had complete coverage solarization for 8 weeks and

high tunnel where no soil solarization took place. The treatments in the sub-plots included two indeterminate commercial tomato varieties (Anna F1 and Tylka F1) un-grafted, and the same varieties grafted on different rootstocks (*Solanum incanum*, Cherry tomato, Mt56, TKA 193-31). The sub-plot treatments were replicated five times in both main tunnels.

Data collection on plant growth (height in cm) and wilt incidence commenced after one month (September 12, 2012) and recorded no wilt incidence during the first month in all the tomato plants. However, wilt incidence has so far been recorded mostly on ungrafted tomato variety Tylka F1. No bacterial wilt incidence had been recorded from any grafted plant as of September 30, 2012.

In-vitro evaluation of *Trichoderma* strains for their potential in suppressing *R. solanacearum*

Sylvia K, G. Tusiime, Waiganjo M, M. Wepukhulu, S; Erbaugh, S. Miller, S. Kyamanywa.

This experiment was carried out at KARI-Thika, Kenya. *Trichoderma harzianum* T22 (Trianum®) was provided by Koppert Biological Systems, *Trichoderma asperellum* and Rootgard were purchased from Real IPM (K) Limited and Juanco Biologicals LTD respectively. The inoculums were extracted from wilted tomato plants that were collected from Kaburuge village, Muranga County. The bacterial solution was standardized based on the McFarland turbidity standard to about 9x108 bacterial cells/ml. Data was collected on the size of *Trichoderma* fungal overgrowth over the bacterial culture.

The *Trichoderma* fungi overgrew the bacterial culture. *Trichoderma harzianum* strain T22 had the most overgrowth (3.94) followed by *T. asperellum* strain T-203 (3.20), while the least overgrowth was recorded on Rootgard (0.76), which had only slight overgrowth compared with the control (0.0). *Ralstonia solanacearum* was affected by overgrowth and lysis. This mechanism is involved in the biological control property of *Trichoderma*.

Passion fruit

Validation of virus detection procedures and establishment of clean virus free passion fruit mother block seedling nursery at KARI Thika

Miriam Otipa, Ruth Amata, M. Waiganjo, Juster Gitonga, Simon Wepukhulu, Sally Miller, Mark Erbaugh

Virus isolates were mechanically inoculated on indicator plants of *Nicotiana benthaamiana* and *Chenopodium quinoa, Phaseolus vulgaris* and lima beans raised from certified seeds at Ohio State University and KARI-Kabete. Plants were maintained in the greenhouse and evaluated weekly for local and systemic infection for up to 30 days after inoculation. Total RNA was extracted using the CTAB method, and RT-PCR was performed using specific primers to determine the presence of the *Kenya passion fruit virus* (KPFV) on indicator plants. A repeat experiment was initiated in the greenhouse at KEPHIS-Muguga with *Nicotiana* species*, Chenopodium* species, common beans, lima beans, two varieties of cowpeas, and passion fruit (yellow and purple). These plants were inoculated with virus isolates from different agro ecological zones (AEZ) for biological characterization.

Common beans (*P.vulgaries*), lima beans, and *Nicotiana benthamiana* exhibited symptoms clearly while *C. quinoa* did not.

To determine the molecular characterization of viruses from different agro ecological zones, the total RNA was extracted from 845 symptomatic and asymptomatic plants using Qiagen kit and used as a template for RT-PCR to generate 1st strand complementary DNA. The deduced amino acid (aa) sequences of the polyprotein gene of KPFV were compared to sequences of other potyvirus isolates available in the GeneBank. Pairwise comparisons among the sequences indicated aa identity levels of 83% to100%. A fragment of 567 bp of 3'RACE was identified. After several rounds of cloning, we have close to 9900 nucleotides. The highest aa identity levels were observed with *Bean common mosaic virus*, *Wisteria vein mosaic virus*, and *Watermelon mosaic virus*. The phylogenetic tree based on the complete CP aa sequences clearly indicates a close relationship between KPFV and isolates from Brazil, South Africa, Nigeria, and Morocco**.** New strains MO8-9, MO2-7, and MO2-7M are more closely related to each other than they are related with A23596, which is near full length

To determine molecular variability of passion fruit viruses in diseased passion fruit from different agroecological zones two primer pairs were designed and used to determine the presence of KPFV in diseased plants from different areas using the RevertAid First Strand cDNA Synthesis Kit. cDNA products were amplified using KPFV-MOR1 and MOF1. Amplified products were purified using DNA Clean and Concentration Kit and the fragments digested with (MluI and EcoRV) enzymes to classify the strains of the virus from each region.

Results: In the tested samples 73.9% were found to be positive to strain 19,

Table 8. Mean number of thrips and damage score ± SE (onion)

Treatment	**Damage**	**Number of thrips**
Need-based pesticide application after scouting (spray Confidor during second month after transplanting, 2nd Month and Decis 3rd Month A.T.P.	0.056 ± 0.022c	2.713d ± 0.171
Farmer practice (Spray with Decis at 4 weeks A.T.P. and fortnightly thereafter.	0.200 ± 0.040c	3.925c ± 0.337
Needbased pesticide application after scouting and use of biopesticides (Biopower/ Metarhizium at 4 weeks A.T.P., alternating with Achook and Decis.	0.206 ± 0.052c	4.544c ± 0.401
Need-based pesticide application starting as in 1 but starting from 2nd month and 3rd month.	0.481 ± 0.062b	6.663b ± 0.489
Control (No insecticide application)	1.263 ± 0.066a	14.100a ± 0.467
Cv	18.21150	30.36327
p-value	<.0001	<.0001

Figure 5. Onion thrips population during the crop development in different treatments at KARI-Thika.

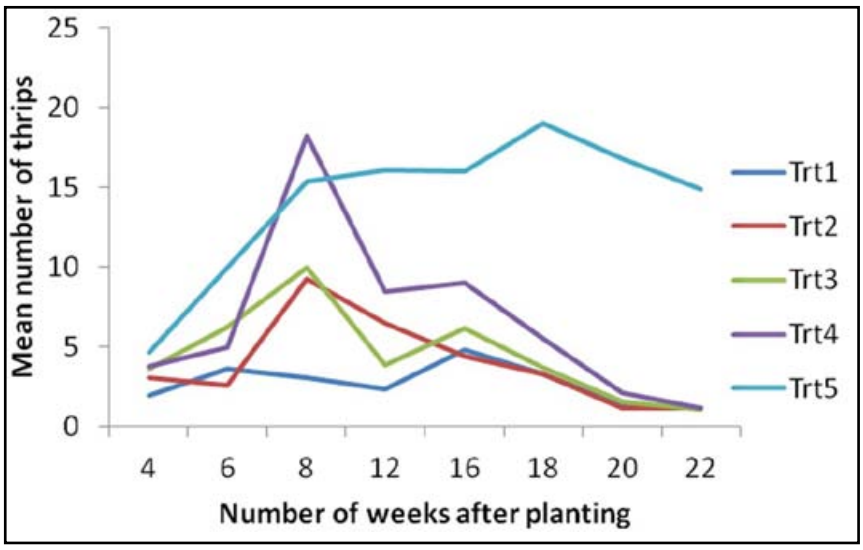
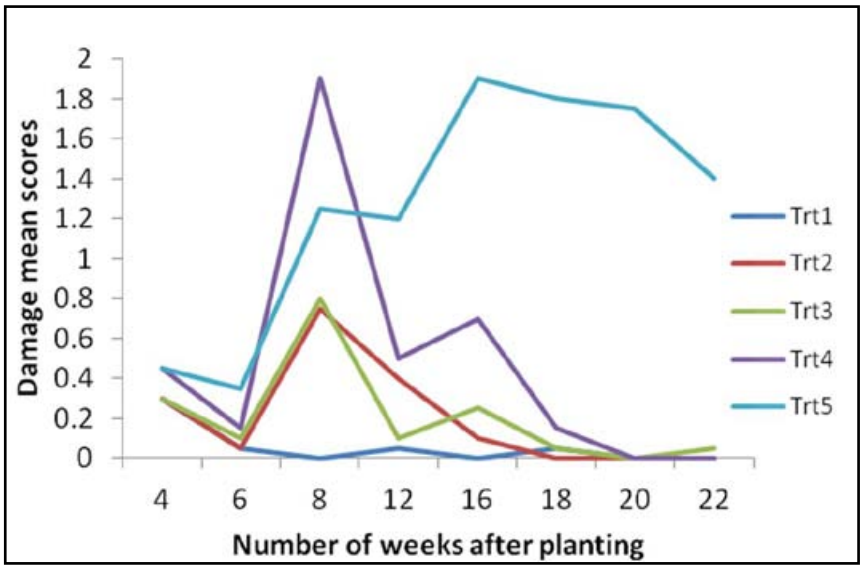


Figure 6. Mean thrips and damage in onion at an on-station field trial at KARI-Thika



47.8% to strain 28, and 21% had mixed infections. Two primer pairs that were developed are being used to screen and clean passion fruit plants in the KARI-Thika nursery to establish clean planting materials.

Onion

Development of action thresholds for onion infesting thrips

Waiganjo M; Amata, R; Wepukhulu, S; Sylvia K; Gitonga, J; M. Erbaugh, S. Miller, D. Taylor, Maerere, J. Kovach

On-station and on-farm trials were conducted to test cost-effective IPM options for management of *Thrips tabaci, Frankliniella occidentalis,* and diseases in onion caused by *Alternaria porri* and *Peronospora destructor*. Onion var. Red creole, the preferred variety by most consumers but susceptible to onion thrips, was used in the on-station trial. Each plot size was 3 m x 3 m. The trial design was in randomized complete blocks consisting of five treatments replicated four times (see tab. 8). The mean number of thrips was significantly different, $p< 0.0001$, but the mean number of thrips due to treatments 2 and 3 were not different from each other. Treatment 1 had the lowest mean number of thrips, and treatment 5 had the highest mean number of thrips (tab. 8).

Thrips population trend during the crop development showed that the 8th week had the peak population for treatment 2, 3, 4 (fig. 5).

The mean damage scores were significantly different, $p< 0.0001$. Treatment 5 differed from treatment 4, and both differed significantly from 1, 2 and 3. Treatments 1, 2, and 3 did not differ significantly. Treatment 1 had the lowest damage score 0.056 while treatment 5 had the highest damage mean score of 1.263 (fig. 6).

The yield from treatment 1 did differ significantly ($p=0.0265$) from treatments 2, 3 and 4 but was significantly different from treatment 5. Treatment 1 had the highest mean weight of 8.750, while the lowest mean weight was from treatment 5 of 2.75.

TANZANIA

Tomato

Impact of management practices on post-harvest physiology and shelf life of tomato

Amon Maerere, Hossea Mtui, Mark Bennett, Sally Miller, Matt Kleinhenz

The purpose of this activity was to assess the effect of different pest management practices (farmer practice, IPM, and pesticide spray based on manufacturer's recommendations) and mulching on tomato shelf-life. IPM was one of the treatments whereby mulching was done and pest control performed after scouting. Fungicides were used for control of early blight (*Alternaria solani*) and late blight (*Phytopthora infestans),* which are the major diseases affecting tomato in the region.

An on-station field experiment was conducted. For the mulched plots, dry grasses (*Panicum* spp.) were applied as mulch three days after transplanting. The grasses were obtained before flowering, sundried, and chopped to approximately 25 cm long. The mulch was then laid down by hand at a thickness of 10 cm, making sure the soil was completely covered.

Three fungicide application regimes were tested: i) weekly sprays (farmers' practice), ii) sprayed when weather conditions were favorable for disease development and/or insect pests at threshold levels were observed after scouting (IPM), and iii) sprays as per the manufacturers' recommendation (MR). Unsprayed plots (F0) were included as a control. The fungicide, Ridomil GOLD® (Metalaxyl-M), which is commonly used for tomato produc-

Figure 7. Effect of mulch on tomato yield.

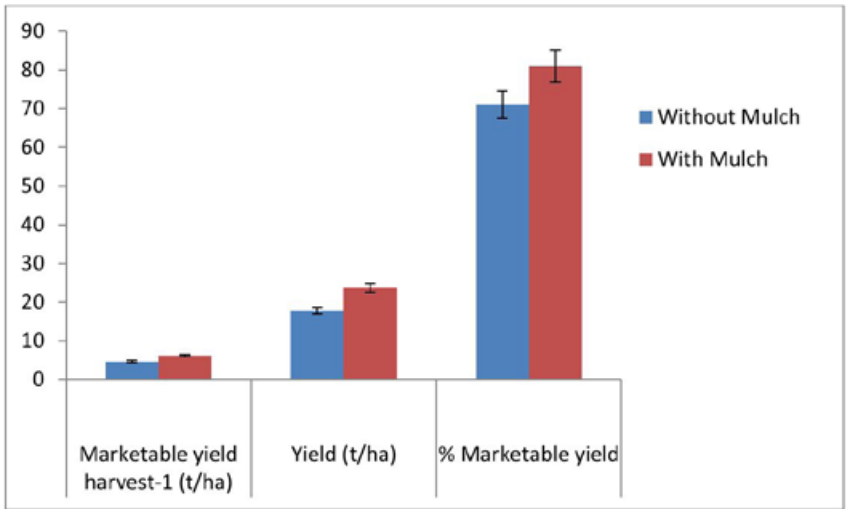


Table 8. Tomato yield and yield components for the two varieties averaged over fungicide regimes and mulch

Variety	Yield components				
	Marketable fruit number plant-1	Average fruit wt (g)	Marketable yield harvest-1 (t/ha)	Yield (t/ha)	% Marketable yield
Tanya VF	8.77[a]	78.1[a]	7.08[b]	27.50[b]	83[b]
Tengeru 97	2.96[b]	115.0[b]	3.71[a]	13.92[a]	69[a]
MEAN	5.87	96.54	5.40	20.71	76
LSD	1.36	13.74	2.09	11.88	7.56
p-value	0.003	0.007	0.020	0.039	0.015

Means followed by the same superscript are not statistically significant different (p≤ 0.05); t/ha = Tons per hectare; LSD = Least significant difference

tion in Morogoro, was used. The fungicide was sprayed fourteen, seven, and four times for the Farmers' Practice (FP), MR, and IPM respectively. The broad spectrum insecticide Selecron® (Profenofos) was used to control insect pests.

Two varieties were used for comparison: Tengeru 97 (semi-indeterminate) and Tanya VF (determinate). Fruits were harvested in the morning and sorting was done. Fruits damaged by pests were recorded and discarded. Marketable yield was calculated based on fruit quality standards acceptable to the local tomato vendors.

(i) Effect of mulching

The results in figure 7 reveal that the use of mulch resulted in plants that produced more fruits (p=0.020) than non-mulched plants. Although the average fruit weight was similar (p=0.05), the average marketable yield per harvest, marketable yield per hectare, and the percentage of marketable produce was higher with mulched compared to the non-mulched plots (p=0.007, p=0.019, p=0.002 respectively).

(ii): Effect of different spray regimes

Marketable tomato fruit yield and yield components were statistically higher when any of fungicide regimes was applied compared to the control. Plants sprayed using any of the three spray regimes (FP, IPM, MR) produced more fruits (p<0.001) and higher fruit weight (p<0.001) compared to the control. There were no statistical differences (p=0.05) between the FP, IPM, and MR spray regimes on yield, yield components, or the percentage of the produce having market value (fig. 7). These results suggest that reduced sprays (IPM) can be used to reduce pesticide use without compromising tomato yields.

(iii): Variety differences on yield

Tengeru 97 was less productive than Tanya VF. The latter had a consistently higher number of marketable fruits per plant (p=0.003), marketable yield per harvest (p=0.020), and total and percentage marketable yield (p= 0.039 and p=0.015 respectively). However, Tangeru 97 had a higher average fruit weight compared to that of Tanya VF (tab. 8).

Coffee

On-station field trial to study effect of existing shade and open-grown coffee on key pests

J.M. Teri, F. L. Magina, A. P. Maerere, K. P Sibuga, D. Mamiro, M. W. Mwatawala

The purpose of this activity was to conduct monitoring of insect pests (white coffee stem borer, coffee berry borer, and antestia bugs), diseases (coffee berry disease, leaf rust), and weeds (star grass, couch grass, and wandering jew) to assess the effects of shade on infestation levels.

Pest and disease monitoring was carried out on a monthly basis and carried out as follows:

i) White coffee stem borer (*Monochumus leuconatus* Pascoe)

The number of WCSB was estimated by examining the lower trunk, up to 0.6 m above the collar level for any signs of stem girdling or boring by white coffee stem borer. The number of holes per tree was recorded for each sampled tree. In each hole with emission of frass we assumed one larva. Adult beetles observed on trees sampled were also counted.

ii) Antestia bug (*Antestiopsis spp.*)

Population density was estimated by examining the trees for the presence of the pest without disturbing the tree canopy. The total number of adults and nymphs per bush was recorded.

iii) Coffee berry borer (*Hypothenemus hampei* Ferrari)

The population density was determined by randomly selecting a primary branch-bearing coffee berries in the middle third of the bearing head and two medial berry clusters were examined for the presence of the pest. This was recorded in a modified standard sheet.

iv) Coffee berry disease (*Colletotrichum kahawae*) and coffee leaf rust (*Hemileia vastatrix*)

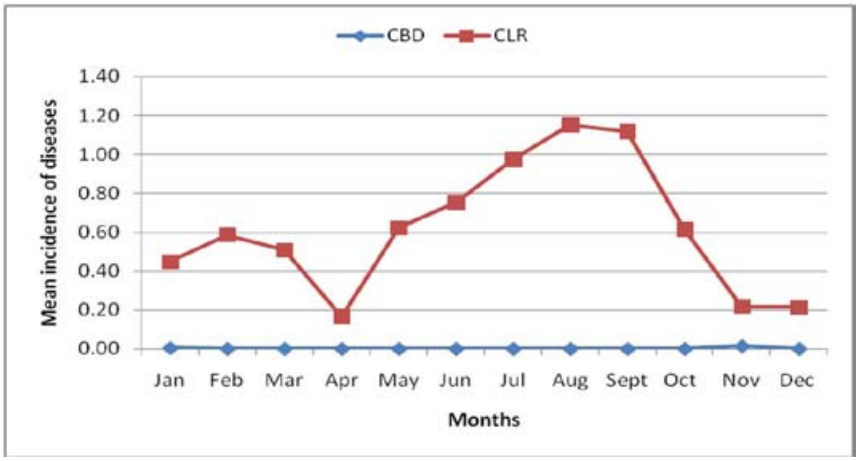


Figure 8.Mean incidence of CBD and CLR per year

Observation of the entire tree canopy was made and severity of infestation by CLR and CBD recorded on a scale of 0 to 4 as follows: 0 = No infestation; 1 = Mild infestation (less than 25% infestation); 2 = Severe infestation (25%–50% infestation); 3 = very severe infestation (50%–75% infestation); 4 = Acute infestation (75%–100% infestation)

v) Weeds

Quadrants measuring 2 m x 2 m (figure 3) replicated 3 times were established in May 2011 in unshaded and coffee plots shaded by banana intercrops at TaCRI Lyamungu. Weed densities of the most prevalent weeds, namely star grass (*Cynodon dactylon*), couch grass (*Digitaria spp.),* and wandering jew (*Commelina spp.*) were assessed every week.

Incidences of CBD and CLR were affected by the level of shading. CLR is more prevalent in shaded than in unshaded coffee plots. CBD incidence was not observed because the disease is not a major problem at the experimental site, which is at medium altitude. CLR is prevalent in the area throughout the year. However, infestation is higher from June to September, when it is cooler than the rest of the year (fig. 8).

The level of shading affected the population level of WCSB, antestia bugs, and CBB. The population of WCSB was slightly higher in unshaded plots followed by sparse shade, and it was lowest under dense shade. This trend was similar to that of the antestia bug, which overall was the most prevalent pest. CBB population level was highest under sparse shade followed by dense shade.

The wandering jew and couch grass established well in both shaded and unshaded coffee fields. *Commelina* spp. was the most dominant and more prevalent in unshaded plots. Star grass was least prevalent under both conditions.

Coffee berry borer management using traps and parasitoids

J. M. Teri, F. L Magina, A.P Maerere, K. P Sibuga, D. Mamiro, M. W. Mwatawala, J. Kovach

This activity had two objectives: (i) to conduct on-station rearing of parasitoids for Arabica coffee and their release in the field and (ii) to conduct evaluation of the efficacy of locally-made traps in trapping coffee berry borer in Arabica and Robusta coffee.

The study was conducted on station in an insectary at TaCRI, Lyamungu. Coffee berries were collected from the coffee fields on the station. Parasitoid emergence was assessed, and parasitoids were collected and sent to the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi in Kenya for identification. Fruit flies that emerged from the same berries were also collected and preserved in 75% ethanol and sent to Sokoine University of Agriculture (SUA), Morogoro, for identification.

CBB traps were installed on Arabica coffee farms in Lushoto and Mbozi districts starting from May 2011 to June 2012, while in Robusta coffee they were installed at Maruku (Kagera) October 2011 to September 2012. They consisted of six treatments made of local brews commonly used in each ecological zone. A split plot experiment arranged in a randomized complete block design (RCBD) with 3 replications was used. The main factor consisted of colored lure containers (bottles painted white, red, and blue), and sub-factors were types of trapping lures (5 types) and water as control. The study was conducted during the whole year and covered the flowering, fruit setting, and harvesting stage of coffee.

A total of 42 parasitoids emerged 21 to 25 days after incubation of coffee berries collected from the fields. Among them, two bethylid wasps considered to be potential parasitoids of CBB for Arabica and Robusta coffee in the study area were identified. These are *Cephalonomia stephanoderis* and *Prorops nasuta* (figs. 9a and b, respectively). Rearing of the parasitoids for mass multiplication has been initiated in collaboration with International Centre for Insect Physiology and Ecology (ICIPE).

Moreover, three fruit fly species emerged from the same berries between 5 and 7 days after incubation, and they were identified as *Ceratitis capitata*, *Ceratitis rosa*, and *Trirhithrum coffeae* (figs. 9 c, d, and e respectively). The flies are known pests of other fruit crops. Consequently, assessment of their economic importance in coffee production in the area has been recommended.

Juices alone followed by their 1:1 mixtures with methylated spirit attracted more pests (CBB) in all locations.

Figure 9: Parasitoids (a) *Cephalonomia stephanoderis* and b) *Prorops nasuta*. Fruit flies (c) *Ceratitis rosa*, (d) *Ceratitis capitata*, and (e) *Trirhithrum coffeae*

Table 9. Mean onion yield as an effect of weeding

Weeding regimes	Mean Yield (g)	SS	MS	df	F-value
Weeding times					
No weeding	661.5	8588123.4	4294061.7	2	14.3*
Weeding once	1536.8	7210905.8	300454.4	24	
Weeding twice	2024.7				
Variety					
Mangola Red	1569.3	405088.5	202544.2	2	0.32ns
Red Creole	1272.8	153939.4	641414.2	24	
Red Bombay	1380.9				

KEY: ns= Not significant; *= statistically significant at p< 0.05

Table 10. Mean diameter of onion bulb harvested as an effect of weeding

Diameter of large size bulb					
	Mean diameter (CM)	SS	MS	df	F-value
Weeding times					
No weeding	3.5	3.83	1,92	2	7.34*
Weeding once	4.27	6.26	0.26	24	
Weeding twice	4.4				
Variety					
Mangola Red	3.9	0.33	0.17	2	0.412ns
Red Creole	4.1	9.8	0.41	24	
Red Bombay	4.2				

KEY: ns= Not significant; *= statistically significant at p< 0.05

Lures in red color (RC) performed better in trapping pests than blue (BC) and white (WC) colored containers.

Onion

Weed management

Amon Maerere, Kallunde Sibuga, M.W Mwatawala, C.P Msuya-Bengesi, E.R Mgembe, Delphina Mamiro, K.K.,Mwajombe, Dunstan Mtui, M. Erbaugh

The overall purpose of this activity is to **e**valuate cultural weed management options (mulching, stale seedbed technique, post-emergent herbicide, and weeding frequency) on-station for one season before transfer on-farm. Three onions varieties and three weeding regimes were used. The experiment consisted of a complete randomized block design (CRBD) with three replications. Plots had the dimension of 3 m x 3 m. Data on weed load, onion yield, onion bulb number, and onion bulb diameters were collected and analyzed.

The results (tab. 9) show that sedge and grass weed load declined when weeding was done twice, compared to weeding only once. However, the results indicate that broad leaf weeds load increased with increased weeding. Overall, differences in weed load between weeding regimes were not found to be statistically significant at p< 0.05.

Weed loads were found to be higher under Red Bombay variety for all the measured weeds, but sedge weed loads were found to be lower in Red Creole plots, while lower broad-leaved weeds were lower in Mangola Red plots. The weed loads based on dry weights of grass weeds were significantly different between onion varieties at p< 0.05. Comparison of the amount of weeds between two weed harvesting periods in all three types of weeds showed that weed loads tended to decline with increased numbers of weeding.

Different weed regimes were also examined to compare their effects on the performance of onions varieties in terms of yield and onion bulb size. Results (tab. 9) show that mean onion yield increased with increase in number of weeding times. The yield was more than twice by weeding once and tripled when weeding was done twice.

The effect of weeding times on overall mean yield of onion was found to be statistically significant at p< 0.05. However, there were no statistical differences on onion yield between varieties, but a significant increase in yields was observed for Red Bombay and Red Creole varieties as an effect of increased weeding times

The effects of weeding on sizes of individual onion bulbs harvested are shown in table 10. The diameter of harvested onion bulbs was found to be smaller with no weeding applied and found to be larger when weeding was done twice

Evaluate onion insect pests and disease management options

Amon Maerere, Kallunde Sibuga, M.W Mwatawala, C.P Msuya-Bengesi, E.R Mgembe, Delphina Mamiro, K.K.,Mwajombe, Dunstan Mtui, M. Erbaugh

Field and on-farm trials were conducted to evaluate different insect pests and disease management options (mulching, trap and repellant plants, resistant varieties, and time of planting). Major insect pest and disease incidences, type of damage, and onion yields will be assessed. Effectiveness of each pests and disease management options will be compared.

Assessing the types of insect pests and disease incidences is on-going. Upon completion of data analysis, observed insect and disease problems and their importance will be identified and ranked.

Preliminary results indicate that thrips (*Thrips tabaci*) are the major insect problems observed on station and in the project target villages. In terms of diseases, purple blotch (*Alternaria pori)* was found to be the most serious. The onion grub *(Phyllophaga spp.)*, not observed on station at SUA, was identified as a soilborne pest in villages in Kilosa and Kilolo districts. This confirms farmers' reports during baseline studies.

Varietal evaluation and fertilizers application

Amon Maerere, Kallunde Sibuga, M.W Mwatawala, C.P Msuya-Bengesi, E.R Mgembe, Delphina Mamiro, K.K.,Mwajombe, Dunstan Mtui, M. Erbaugh

The purpose of this activity was to evaluate the performance of a wide range of onion germplasm under local conditions with targeted villages in respect to adaptability, fertilizer response, and the direct/indirect effects on plant health and tolerance to pests.

Table 11: Onion farmer groups for Msosa, Malolo B, and Chabi villages

Village name	Msosa	Malolo B	Chabi	Mateteni
Farmers' group name	Tupendane	Upendo	Tetema	Juhudi
Female members	11	11	5	9
Male members	5	14	20	11
Total members	16	25	25	20
Onion varieties	Mang'ola Red Khaki (ex Texas Grano) Red Bombay Red Creole	Mang'ola Red Red Bombay Red Creole	Mang'ola Red Khaki (ex Texas Grano) Red Bombay Red Creole	Mang'ola Red Red Bombay Red Creole

Farmer groups were formed at Msosa, Malolo B, and Chabi villages. At Mateteni, the tomato growers' group (Juhudi Group) was retained for IPM onion production as well (tab. 11). Visits were conducted in major onion growing areas in the country to explore the range of onion varieties grown. Seeds of available varieties were bought from agro-dealers and used to establish trials at the four sites.

The varieties were evaluated for yield performance and to pest and disease resistance. The trials at each site were conducted under the management of the contact farmers and supervision of research associates who conducted bi-monthly visits.

The trials were largely farmer managed, involving land preparation, nursery establishment, nursery management, seedling transplanting, and crop management. The four most common onion varieties found in the Eastern, Northern, and Southern highland zones were Red Bombay, Red Creole, Mangola red, and Texas Grano, also known as Khaki. Similarly, only seeds of these varieties could be found in shops. Thus the current onion germplasm available in the country is very narrow. At Malolo B and Mateteni, variety Texas Grano was not included in the trials because farmers rejected it basis of known low performance and pungency.

All plants were stolen at Malolo B village and re-establishment of the nursery was not attempted as it was already late in the season. Overall, variety Red Bombay performed better in terms of plant growth, bulb size and total yield. Plant growth of Red Creole was generally poor, leading to poor crop stand, smaller bulbs, and comparatively low yield.

COORDINATION WITH GLOBAL THEMES

Impact Assessment

Adoption of IPM technologies in hot pepper farm enterprises in southwestern Uganda

J. Bonabana-Wabbi, J. Kirinya, D.B. Taylor

Hot pepper is an important fresh export crop in Uganda. Europe is Uganda's largest trading partner for hot pepper. However use of pesticides and fungicides to avoid the risk of yield loss due to pests often leads to Ugandan hot pepper farmers' failure to comply with international food safety standards. The objective of the study was to determine farmers' use of alternative pest management technologies as intermediate steps in meeting the GlobalGAP and EurepGAP standards on pesticide-free fresh produce export of hot pepper. A censored Tobit model was fit to understand the adoption intensity of three IPM technologies on hot pepper: ridging, irrigation and minimal pesticide use. All three IPM technologies were found to be widely adopted in the study area, with adoption enhanced by education, access to credit, knowledge about alternative pest management strategies, access to training, and exposure to information sessions by hot pepper farmers. Increased access to these services will be critical for enhanced adoption of practices that may improve farmer's ability to comply with international standards for export commodities.

Passion fruit baseline survey in Central Uganda

J. Bonabana-Wabbi, P. Sseruwagi, M. Ochwo-Ssemakula, D.B Taylor, M. Mangheni, M. Otim, G. Norton, M. Erbaugh, S. Kyamanywa, and Robina Atukunda

A preliminary analysis of a survey of 55 passion fruit farmers from Buikwe, Mubende, and Mpigi districts indicates that passion fruit was mainly grown as a cash crop alongside other crops like banana, coffee, beans, maize, sweet potato, cassava, eggplant, and cabbage in plots of less than 1 acre. Farmers had an average of 5.3 years of farming experience. The most common varieties were Kawanda Hybrid, yellow, and the local purple variety. A typical respondent was male, with less than a secondary level education. Eighty-one percent of the farmers used grafted material obtained from either their own garden (60%), nurseries (12.7%), from fellow farmers (14.5%), or from the market (5.4%).

Willingness to pay to avoid consumption of pesticide residues in Uganda: An experimental auction approach

J. Bonabana-Wabbi, D.B. Taylor

Experimental auctions were used to determine factors affecting Ugandan rural and urban populations' willingness to pay (WTP) to avoid consuming pesticide residues. Information or type of proxy good did not affect WTP, while education had no effect in the urban population and a negative effect in the rural population. Male respondents had a higher willingness to pay than female respondents in both samples. Free riding behavior was observed in both populations.

Table 12: Coffee land and trees per acre

Variable	Participants	Non-participants	Sample	T
Coffee tree count	983 (827)	558 (558)	770 (733)	7.23**
Acres in coffee	1.81 (1.23)	1.33 (0.87)	1.57 (1.09)	1.75*
Coffee trees per acre	560 (281)	422 (237)	491 (268)	5.01**

Values in parentheses are standard deviations;
*t-test significant at p<.05;
** t-test significant at p<.01

Table 13: Quantity produced, yields, and gross income

Variable	Participants	Non-participants	Sample	T
Quantity produced (kg)	1360	404	882	1.67*
Yield (production/coffee acres)	751 kg/ac	304 kg/ac	562 kg/ac	4.24**
Gross income (UGsh)	4,325,546	1,851,888	3,088,717	6.11**

*t-test significant at p<.05;
** t-test significant at p<.01

Table 14: Gross margins

	Participants	Non-participants
Subtotal labor costs	1,793,357	902,622
Subtotal transport/process costs	307,165	249,296
Subtotal input costs	373,948	157,315
Total variable costs	2,474,470 ($990)	1,309,232 ($524)
Total coffee income	4,325,546	1,851,888
Gross margins	1,851,077 ($740)	542,656 ($217)

Table 15: Practice differences as a result of participation in ICM PAR program

Variable	Participants	Non-participants	Sample
Yield (kg/acre)	751 kg/ac	304 kg/ac	562 kg/ac
Improved coffee varieties	100%	29%	
Coffee trees per acre	560 (281)	422 (237)	491 (268)

Values in parentheses are standard deviations.

Assessing impacts of participatory agricultural research on yields and profitability of Arabica coffee farmers in Manafwa District, Uganda

Rosemary E. Isoto, J. Mark Erbaugh, S. David Kraybill

The main purpose of this study was to assess the impact of IPM CRSP participatory agricultural research (PAR) on the yields and profitability of Arabica coffee farmers in Manafwa district.

The IPM CRSP, in collaboration with the Ugandan Coffee Research Centre (COREC), has been using a participatory agricultural research (PAR) approach with Arabica coffee producers in Manafwa district, Uganda, since 2007. In keeping with this approach, scientists and local extension providers worked with small groups of farmers, engaging them in each step of the research and technology development process from problem identification to on-farm testing of improved management practices. Demonstration trials and training took place on-farm and included field days during which groups viewed and discussed various tactics and improved technologies and practices.

A multi-staged sampling procedure was used to select farmers from two sub-counties in Manafwa district for interviewing. A systematic random sample of 21 farmers per sub-county was selected from lists of PAR participants, and 21 non-participants per sub-county were selected from lists provided by the District Agricultural Office. Non-participants were those who had not participated in any PAR activities conducted by the IPM CRSP team. The final sample consisted of 42 participants and non-participants per sub-county for a total sample size of 84.

Gross margin analysis (GMA) was used to assess the impacts of PAR activities on production and profitability. Gross margins are calculated by establishing the output and total revenue and then subtracting total variable cost for both farmer participants and participants.

The tables provide a comparison of Arabica coffee production, variable costs, and gross margins between those who participated in coffee PAR activities and those who did not. Table 12 presents the findings on number of trees, acres in coffee, and trees per acre owned by each of the group categories. Participant farmers had more coffee trees, more acres in coffee, and more trees per acre than non-participating farmers.

Table 13 indicates that participating farmers produced more coffee (1360 kgs) than non-participating farmers (404 kgs) and had higher yields per acre (751 vs. 304 kgs/ac); this resulted in their having higher annual coffee incomes of $3751 vs. $1114. Participating farmers also had higher variable labor, transportation, and processing and input costs than non-participating farmers.

Gross margin analysis indicates that participants in the PAR program had higher per acre yields (751kgs/acre) than non-participants (305 kg/acre); and that participants incurred higher total variable costs ($990) per acre than non participants ($524) (tab. 14). These variable costs included labor, post handling/harvest, and input costs. Participants' gross margins were $740 per acre, and those for non-participants were $217 per acre, indicating substantially higher gross margins for participants in the PAR program.

Production practices: The PAR training program covered topics on both IPM and ICM to improve coffee production. To attribute increased income and benefits to the program, the two groups were compared on their use of specific programmatic recommendations (tab. 15). Participants had higher per acre yields than non-participants. One reason for this may be attributed to participants growing more trees per acre, or higher tree

densities, than non-participants. The rule-of-thumb standard for coffee trees per acre is 600/acre, and participants were closer to this standard than were non-participants. Many small scale growers use wide spacing between trees so they can produce other food crops, such as beans and bananas. Another reason participants may have had higher yields was that they were more likely to be using improved coffee varieties that are higher yielding and more disease tolerant. All participants were found to be growing at least one of the improved coffee varieties, including 31 (74%) growing SL-14, 10 (24%) growing KP-423, and one (2%) growing SL-l28 (2%). To the contrary only 12 (29%) non-participants were using the improved variety SL-14, while the remaining 30 (71.43%) non-participants were using local unimproved varieties like Bugisu local.

Gender Knowledge

Development of the women participation checklist

Margaret Najjingo Mangheni, Richard Miiro

A checklist was developed in consultation with the US based GGT Coordinator that will be used to target women and monitor their participation in each project site. It was shared with the research scientists at the RP annual planning meeting held in Kampala, Uganda. The purpose of the presentation was to (a) get feedback/comments from scientists on the checklist (b) sensitize scientists about barriers to women's participation in project activities, and the importance of systematic monitoring and targeting of women. The checklist presents a cost effective and efficient means of collecting gender disaggregated data from all projects in the three countries. Information from each project site will be collected by the country GGT coordinators while the GGT regional coordinator will compile the data for the three countries.

Socio-economic survey of coffee growers in Eastern Uganda

Margaret Najjingo Mangheni, Richard Miiro

A study of gender-based constraints and opportunities for IPM of the coffee stem borer in Sironko and Manafwa districts, Eastern Uganda, was conducted. Data was collected through review of literature, key informant interviews, and an individual surveys. Thirteen key informants were interviewed including six farmer leaders, four extension workers, and three research scientists involved in the IPM CRSP activities. The survey had a total sample of 150, with equal numbers of males and females.

Stem smoothening was perceived to be effective against the pest, though labor intensive. Another constraint is that it involves bending for a long time, which is uncomfortable for the elderly and women. For stem wrapping, termites destroy the banana wrappings making it not cost-effective in terms of the labor.

Other identified key barriers to women's participation included heavy workload, long distance to IPM demo sites, and cultural restriction on mobility and participation in leadership. Women also have less access and control over coffee benefits compared to men, which acts as a disincentive to women's engagement in IPM. It is recommended that the project: organize demo sites at parish level so as to reduce the distance farmers have to travel; and conduct more gender sensitization for men and women as well as specific gender and leadership training for women farmers as part of the IPM farmer field school curriculum. In addition, the project should broaden the communication channels beyond group training to include women-friendly channels, such as placement of posters in places frequented by women.

Plant Viruses

Developing diagnostic standard operating procedures (SOPs) and fact sheets on prioritized diseases of tomato and passion fruit in East Africa

Sseruwagi, P., Kinyua, Z., R. Amata, M., Otipa, M. Waiganjo, S. Kyamanywa, M. Ochwo-Ssemakula, G. Tusiime, A. Maerere, S. Miller, M. Erbaugh

The task included testing and dissemination of standard procedures for diagnosis of major viral diseases affecting tomatoes and passion fruit in the region. SOPs were developed using information collated on the diagnostic techniques/tools available for major virus diseases of tomato and passion fruit, along with the identified knowledge gaps. Scientists from the three countries with specialties in diagnostics were brought together in a residential workshop and assigned tasks to develop specific SOPs and fact sheets. The drafts were discussed and refined.

So far, three SOPs have been developed on tomato, passion fruit, and hot pepper viruses by different teams in a workshop held at Kenya Agricultural Research Institute (KARI), Kabete.

- Standard Operating Procedure for Plant Diagnostic Laboratories - *Tomato yellow leaf curl virus* (TYLCV) by P. Sseruwagi, D. Mamiro, J. Nduguru, I. Ramanthani, S. Tolin, F. Qu.
- Standard Operating Procedure for Plant Diagnostic Laboratories - *Passion fruit woodiness virus* (PWV) by M. Otipa, P. Sseruwagi, J. Nduguru, M. Kasina, S. Tolin, F. Qu.
- Standard Operating Procedure for Plant Diagnostic Laboratories - *Cucumber mosaic virus* (CMV) by I. Ramanthani, J. Karungi, W. Arinaitwe, Z. Kinyua

Two of the SOPs (TYLCV and PWV) were tested in a workshop at Sokoine University of Agriculture, Morogoro, Tanzania, held April 30–May 5, 2012.

Developing diagnostic and management fact sheets and posters on prioritized diseases of tomato, passion fruit, and onion in East Africa

Kinyua, Z.M., R.L. Amata, M.J. Otipa, P. Sseruwaji, M. Ochwo-Ssemakula, G. Tusiime, D. Mamiro, J. Karungi, S. Miller, M. Erbaugh, F. Beed, D.W. Miano, G.M. Kariuki, M. Mangheni

In order to enhance the capacity of farmers and extension staff to easily recognize and diagnose/identify key pests and diseases in the production of tomatoes, passion fruit, and onions in Kenya, Uganda, and Tanzania, quick guide reference materials were envisaged as a critical requirement. The reference materials were in the form of fact sheets and posters that would also provide information on the choice and application of preventative and management strategies against priority pests and diseases. Teams of scientists within the three target countries were formed to develop fact sheets as a starting point. This activity drew representatives from partners involved in the IPDN, IPVD, and East Africa regional projects. The task

involved the use of literature searches, on-farm observations, information collation, consolidation of information, and pictorials. Coordination of this activity mainly relied on email and telephone communications among the team members.

Nine fact sheets have been developed for use in training of farmers and agricultural extension staff. The fact sheets, which are in the final drafting stage, are on the following areas: passion fruit viruses; *Tomato spotted wilt virus*; *Tomato mosaic virus*; *Tomato yellow leaf curl virus*; tomato bacterial wilt; tomato root knot nematodes; pepper viruses; onion thrips; and passion fruit collar rot. The fact sheets consist of pictorial illustrations (symptoms mainly) and brief descriptions to aid in identification/diagnosis and management of the respective pests and diseases.

The final draft fact sheets are to be pre-tested and refined through focus group discussions with farmers and agricultural extension staff before final printing. Literature searches (grey & published) and visits/interviews with a selection of farmer groups and extension agents in East Africa will further assist in final refinement of the fact sheets. The information in the finalized fact sheets will subsequently be synthesized into posters that will provide a variation of knowledge-sharing products.