Ecologically-Based Participatory IPM for Southeast Asia

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Summary

In this phase of the IPM CRSP Cambodia was added to the countries involved with the IPM CRSP in the region. The objectives of the project in Cambodia are focused on transfer of proven IPM tactics developed and implemented during previous phases of the IPM CRSP. To this end, after meetings with an array of government and NGO organizations currently active in agricultural development projects with the purpose of identifying appropriate collaborators the National IPM Program, housed in the General Directorate of Agriculture, was selected and initial activities were begun.

With the beginning of phase IV, some of the regional project's previous collaborators were deleted from the program while the collaborators best suited to the technology transfer emphasis of the new phase were strengthened. In the Philippines, PhilRice and the University of the Philippines at Los Banos are the leading institutions. Each is focusing on vegetable IPM in their respective regions. Eggplant, onion, tomato, bitter gourd, and chilies are the major vegetables for these efforts.

In Indonesia, collaborators continue to be the *Institut Pertanian Bogor* (IPB) in West Java, Sam Ratulangi University in North Sulawesi, and FIELD/Indonesia which conducts farmer training in technology transfer activities in North and West Sumatera. The USAID Mission in Jakarta is emphasizing high value crops in their Mission strategy, which meshes well with the IPM CRSP program already established in Indonesia. Vegetables, including tomato, peppers, onion, and crucifers, are important high value crops that the IPM CRSP has been working with for many years. Fruits, including papaya, are important because of their high value income generation, but also because recent attacks by the papaya mealybug provide a significant need for IPM intervention. IPM CRSP collaborators in Indonesia are conducting field tests and outreach activities that directly relate to the USAID strategy.

Indonesia

Institut Pertanian Bogor, Bogor, West Java

Papaya

Economic impact of the papaya mealybug invasion

Ivakdalam L, A Nurmansyah, D Sartiami, A. Rauf, M. Hammig

Papaya (*Carica papaya* L.) is one of the important horticultural crops in Indonesia. Based on the consumption rate per capita, the economic potential of papaya ranks second

Table 1: Benefits and costs analysis of papaya cultivation before the invasion of Papaya mealybug in subdistrict of Sukaraja, Bogor

Farm enterprises Component	Village				Mean
	Cikeas	Sukaraja	Sukatani	Nagrak	
Production costs (million rp/ha)	45.6	41.5	42.7	41.0	42.7
Yield (ton/ha)	158.6	158.9	177.8	186.3	170.4
Revenue (million rp/ha)	142.7	143.1	160.0	167.7	153.4
Profit (million rp/ha)	97.2	101.5	117.4	126.6	110.7
R/C	3.13	3.44	3.75	4.09	3.59

after banana. In mid 2008, thousands of papaya trees in Bogor died because of a new pest, *Paracoccus marginatus* (Hemiptera: Pseudococcidae). The most severely infested papaya plantings were in the subdistrict of Sukaraja. As a result of the outbreak of papaya mealybug, most papaya farmers replaced their plants with cassava plants. A survey was conducted from August to October 2009, with the objective to assess the economic impacts of the papaya mealybug infestation.

The survey was conducted by interviewing 40 papaya farmers spread across four villages (10 respondents per village). The economic impact of the papaya mealybug infestation was assessed using simple benefits and costs ratio analysis for a one year period at the time before and after the arrival of papaya mealybug, as well as after farmers switched to cassava cultivation. The results of the analyses are presented in Tables 1, 2, and 3.

Prior to the invasion of papaya mealybug, the average papaya production was about 170 tons/ha (Table 1). Papaya cultivation required a substantial capital. The average production cost was 42.7 million rupiahs per hectare, of which the largest expenditures were for fertilizer and labor. In spite of that, the papaya business was very promising (R / C = 3.59) because the average profit that farmers gained from this business was about 110 million rupiahs per hectare. Apparently, this gain had attracted many residents, especially those who had capital, into the papaya cultivation.

After the infestation of papaya mealybug, yield declined from the previous year, to an average of 71.7 ton / ha (Table 2) or a decrease in

Table 2: Benefits and costs analysis of papaya cultivation after the invasion of Papaya mealybug in subdistrict of Sukaraja, Bogor

Farm enterprises Component	Village				Mean
	Cikeas	Sukaraja	Sukatani	Nagrak	
Production costs (million rp/ha)	58.0	86.9	83.2	86.8	78.7
Yield (ton/ha)	83.7	74.5	69.7	59.1	71.7
Revenue (million rp/ha)	75.3	67.0	62.7	53.2	64.6
Profit (million rp/ha)	17.3	-19.9	-20.5	-33.6	-14.2
R/C	1.29	0.77	0.75	0.61	0.82

production of around 58%. At the same time, the production costs increased from the previous amount of 42 million rupiahs per hectare to 78 million rupiahs per hectare, an increase of approximately 46%. This cost increase was caused by the increased use of insecticides. Before the mealybug infestation, papaya farmers usually applied insecticides once a month, but after the attack, the farmers increased the frequency of insecticide application to every week or even with some of the farmers, every three days. The average cost increased from 2.0 million rupiahs to 5.7 million rupiahs, an increase of 3.7 million rupiahs. As a result of the increase in production costs and decrease in production, the profit that farmers gained decreased and they even suffered a financial loss as shown with the value of R / C in Table 2, which was 0.82.

After the outbreak of the papaya mealybug in 2008, almost all farmers in the subdistrict of Sukaraja replaced papaya with cassava as their main commodity. The commodity replacement was done because the papaya farmers were not able to control this new pest, although they had already sprayed many kinds of insecticides. The reason why the farmers chose cassava as a substitute for papaya was because cassava cultivation did not require as much intensive care as with papaya cultivation. In addition, around the cultivation area there were many tapioca mills that would buy their produce.

Compared to papaya cultivation, the production costs of cassava cultivation were much smaller with an average of 3.3 million rupiahs per hectare (Table 3). This lower cost was due to the method of cassava cultivation which is much simpler than papaya cultivation. The largest portion of the cost was for seed and labor. The price of seeds was 100 rupiahs per stem and the labor needed was about 4.43 men per day. The average yield of cassava was 23.5 ton / ha.

The results showed that the cultivation of cassava still provides benefits to farmers in the four villages surveyed, with an average profit of 13.2 million rupiahs per hectare (Table 3). However, this advantage was much smaller than when the farmers still cultivated papaya without mealybug infestation. At that time, the average profit of papaya farmers was 110.7 million rupiahs per hectare. This means that the profit obtained by farmers was reducing about 88%. In addition to this negative impact on economic profit, the mealybug infestation also affected the income of farm laborers. Papaya cultivation required a lot of laborers for maintenance and harvesting; this was different from the cultivation of cassava. Thus, the shift from papaya to cassava planting was thought to have led to reduced local workforce that could be employed.

Table 3: Benefits and costs analysis of cassava cultivation in subdistrict of Sukaraja, Bogor

Farm enterprises Component	Village				Mean
	Cikeas	Sukaraja	Sukatani	Nagrak	
Production costs (million rp/ha)	2.9	2.8	4.4	2.9	3.3
Yield (ton/ha)	25.6	22.4	27.0	18.9	23.5
Revenue (million rp/ha)	18.0	15.7	18.9	13.2	16.4
Profit (million rp/ha)	15.1	12.8	14.5	10.3	13.2
R/C	6.2	5.5	4.3	4.6	5.1

Culturing of papaya mealybug in the laboratory

Maharani Y, D Sartiami, R Anwar, A Rauf, BM Shepard

Invasion of the papaya mealybug in early 2008 has caused serious damage to papaya production in Bogor. Biological studies of the papaya mealybug were carried out for development of integrated pest management of the pest. To study the development and reproduction of the papaya mealybug in the laboratory. Papaya mealybug was confined in a micro-cell chamber that was comprised of two acrylic plates (2 x 4 cm), with a 1 cm diameter hole in the middle and a piece of papaya leaf placed between the plates. Immature development, adult longevity, and number of eggs laid were checked daily. The female passed through three nymphal instars whereas the male had four nymphal instars. The first instar known as crawlers, are very active and move from one part of the plant to another. Subsequent instars tend to settle and less mobile. The difference in appearance between male and female papaya mealybugs can be determined during the latter part of the second instars when males change their color from yellow to pink. The difference becomes more evident in latter instars and in the adult. Third (prepupa) and fourth (pupa) nymphal instars of males are pink in color and have elongate bodies covered by a cocoon made from fibers of wax. The third nymphal instar of females have oval bodies and are yellow in color.

The adult female has no wings. The total immature developmental time was 26-27 days. Adult females lived for 15 days while males lived for 3 days. When females were reared on a piece of papaya leaf in a micro-cell chamber, numbers of eggs laid was 48.2±5.50 (n=27). In another experiment using caged living papaya seedlings as a source of food, the fecundity averaged 324.6±41.8 (n=10). This indicated that the rearing condition and quality of food affect the fecundity of papaya mealybug. The sex ratio of adults emerging on caged papaya seedlings was female-biased, with the mean proportion of adult females being 88.6±1.4%. To determine whether the papaya mealybug can develop parthenogenetically, twenty virgin females were held individually without males in a micro-cell chamber until they died. None of them laid eggs, indicating that there is no evidence for parthenogenetic reproduction in papaya mealybug.

Predation preference of *Curinus coeruleus* on the papaya mealybug

Pramayudi, N., A. Rauf, B.M. Shepard, E. Benson

The lady beetle, *Curinus coeruleus* (Mulsant) was introduced into Indonesia from Hawaii in 1986 to control leucaena psyllid, *Heteropsylla cubana* Crawford. During the outbreak of the papaya mealybug in Bogor, the beetle was often found associated with the papaya plants infested by the papaya mealybug. Studies were conducted in laboratory with the objectives to determine development and predation preference of the beetle on the papaya mealybug. Our studies revealed that eggs of *C. coeruleus* hatched in 7.00 days. Development of larval first instar took 6.06 days, second instar 5.5 days, third instar 6.11 days, and fourth instar 8.43 days. The pupal stage was 6.66 days. The longevity of male adult was 49.08 days, while that for female was 76.99 days. Number of eggs laid by a single female averaged 145.68. The sex ratio of male to female was 1:3. Life table analysis indicated gross reproductive rate (GRR) was 101.934, net reproductive rate (Ro) 93.776, intrinsic rate of increase (r) 0.073, mean generation time (T) 62.461 days, doubling time (Dt) 9.534 days, and finite rate of increase (λ) was 1.075. In a no-choice test, significantly ($p < 0.001$) higher numbers of nymphal instar I of the mealybug were preyed upon as compared to other instars. Similarly, in a free choice test, the predator significantly preferred nymphal instar I of the mealybug. None of the adult females of papaya mealybug were preyed on by the

Figure 1 : Entomopthoralean-infected (black) and healthy (yellow) mealybugs

predator in a free-choice test. The preference of the predators toward nymphal instar I of the prey was thought to be related to body size. Nymphal instar I is smaller than others and its body is not covered with wax.

Entomophthoralean fungus and parasitoid of the papaya mealybug

Anwar, R., A. Rauf, Pudjianto, G.R. Carner, B.M. Shepard, R. Muniappan

An entomophthoralean fungus tentatively identified as *Neozygites* sp. has been observed in many samples of the papaya mealybug. Infected mealybugs become black in color as compared to yellow in healthy ones (Fig.1). Field surveys on papaya mealybug were conducted in 2009 in papaya plantations in Bogor, Sukabumi, Tangerang, Cianjur, Purwakarta, West Java, and Lebak, Banten. The objective was to determine natural control potential of entomophthoralean fungus on papaya mealybug in the field. Our study showed that the highest level of fungus infection on papaya mealybug occurred at a papaya plantation in Bogor. The vegetative stage was the predominant stage found at almost all locations. Others fungus stages found were primary conidia, conidiophores and saprophytic fungus, especially in Bogor. Papaya mealybug infected by secondary conidia occurred in Bogor and Tanggerang. There was no papaya mealybugs found infected by resting spores. Another study in subdistricts of Sukaraja and Rancabungur, Bogor during March to May 2010 revealed that level of fungus infection varied between stands and times. The level of fungus infection increased whenever the papaya mealybug population was high. It seemed that entomophthoralean fungus, tentatively identified as *Neozygites* sp., offers a great potential for naturally occurring biological control.

Another promising natural enemy was an encyrtid that was recently collected in Bogor. The parasitoid was identified as *Acerophagus papayae* Noyes and Schauff by Dr. Gregory Evans, a taxonomist from USDA. *Acerophagus papayae* is the dominant parasitoid controlling papaya mealybug in Puerto Rico and the Dominican Republic. It is believed that the parasitoid was accidentally introduced into Indonesia along with the host *Paracoccus marginatus*.

Onion

Efficacy of several natural UV protectants for SeNPV

Samsudin, Y.M. Kusumah, T. Santoso, A. Rauf, B.M. Shepard, G. Carner

This experiment aimed to study the effectiveness of several subtances as UV protectants. Several powdered subtances used as protectants were husk charcoal powder, coconut shell charcoal, soot, talcum powder and yam bean powder, whereas the liquid subtances used were molasses, green tea filtrate, turmeric filtrate and yam bean filtrate. Each of the UV protectants, 0.1 mg or 0.1 ml, was added to 10 ml virus suspensions (1.13 x 10^8 PIBs/ml) to make a 1% final concentration. The UV protectants and virus suspension were mixed thoroughly and three drops of each mixture was applied using a Pasteur pipette onto artificial diet in medicine cups. The cups were placed under direct sunlight for 30 minutes at 12.30 -19.00 in the afternoon. Each treatment was repeated 4 times with 30 cups per repeat. After sunlight treatment, a third instar larva of *Spodoptera exigua* was placed into each cup. All of the cups were placed at room temperature.

Based on the OAR (original activity remaining) values, it is showed that 30 minutes exposure to direct sunlight reduced the infectivity of SeNPV as much as 50% of its original potential. Addition of natural compounds, except the talcum powder, effectively reduced the loss of SeNPV infectivity due to direct sunlight exposure, as shown by the RE (relative efficiency) values which are significantly different from the negative control (Table 4). The same result was also observed in the liquid UV protectants treatment. The RE values show that molasses, yam bean filtrate, turmeric filtrate, and green tea filtrate were effective as UV protectants for SeNPV from UV radiation.

Tomato and Chili Pepper

Survey for virus diseases of chili and tomato

Detection and diagnosis of viruses was initially implemented by collecting field samples from West Java for mainly three vegetable crops, i.e. tomatoes, chili pepper, and long bean. Serological technique using ELISA (enzyme-linked immunosorbent assay) was routinely used for early detection method. Further diagnosis using PCR and nucleic acid sequence analysis of the PCR product was undergone when necessary. ELISA of tomatoes and chili pepper was usually conducted using 4 different antisera, i.e. tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), general poty virus, and one additional antisera for chili pepper i.e. chili veinal mottle virus (ChiVMV).

Table 4: OAR dan RE values of powdered UV protectants

Treatments	OAR (%)	RE
Control (-)	54.08	1.00 d
Talcum powder	62.83	1.16 cd
Yam bean powder	69.80	1.29 bc
Husk charcoal powder	78.62	1.45 b
Soot	79.40	1.47 b
Coconut shell charcoal	80.79	1.49 b
Control (+)	100.00	1.85 a

PCR method for detection of geminivirus was also conducted as routine activities since geminivirus infection has become epidemic in tomato and chili pepper in Indonesia for the last few years. Tomato and chili pepper samples from fields at Cipanas, Bogor, West Java, no infection of TMV, CMV, ChiVMV was detected but geminivirus infection was positively detected from 50% of chili pepper samples. This result was not surprising since we have learned from previous surveys, conducted on a yearly basis since 2006, that geminivirus is the predominant virus in tomato and chilli pepper. Geminivirus infection was thought to be associated also with yellow disease in long bean which occurred widely just recently in Indonesia. Specific diagnosis study was conducted by transmission experiment using whitefly and grafting, and intensive PCR based technique using universal primers for CMV, TMV, Luteovirus, CaBMV, Potyvirus, Crinivirus, and Geminivirus. No amplification product was gained except when using universal primers for coat protein core of Potyvirus (MJ1 and MJ2). This PCR product was further used for sequencing and the sequence analysis showed that the virus has the closest relationship with BCMV-BIC isolate VN/YB1, known to cause infection of *Vigna unguiculata* in Vietnam.

Sam Ratulangi University, Manado, North Sulawesi

Tomato

Resistantance of tomatoes varieties to viral diseases

All lines of tomatoes received from AVRDC were infected by different kinds of viral diseases. There is no significant difference in infection of viral diseases among the lines tested.

All the lines showed symptoms of mosaic, necrosis, and chlorosis. The highest percentage of infection was on line WVCT-6 with about 15.5 % followed by WVCT-1, WVCT-5, WVCT-2 and WVCT-8 with 11, 10.5, 7.5 and 7.0 %, respectively. Less than 5% infection was noted in the local varieties Amelia, Anna, Permata and Chung.

Use of Yellow Sticky Traps in Tomato Field

D.T. Sembel, M. Meray, M. Ratulangi, E. Baideng

Yellow Sticky Traps were used for monitoring leafminer, *Liriomyza sativae* and its parasitoids in tomato fields. The traps also caught a few adults of the fruit fly, *Bactrocera papayae*, which has become a serious pest of tomato in North Sulawesi.

Application of Plastic Mulch, Rice Straw Mulch and Yellow Sticky Trap on Tomato Crops

D.T. Sembel, M. Meray, M. Ratulangi, E. Baideng

The population of the leafminer, *Liriomyza sativae* in plots without pesticide was lower than the plots with pesticide sprays. This is in concurrence with reports of other researchers as the populations of the parasitoids are severely affected by the sprays and the leafminer is resistant to most insecticides. The polulation of the leafminer in plots with plastic mulch was much lower than in control plots and plots with rice mulch.

Cabbage

Parasitism of Plutella xylostella by Diadegma eucerophaga in Cabbage

Samples of larvae of *P. xylostella* were collected from cabbage plantations in Rurukan (Tomohon) and Modoinding (South Minahasa) during the period April to August 2010. All samples were individually placed in plastic cups in the laboratory and the number of *P. xylostella* adults and the parasitoid, *D. eucerophaga* emerged were counted. The average parasitism of *P. xylostella* by *D. eucerophaga* on cabbage crops in Rurukan, Tomohon during the period between April to August 2010 was 91%, and at Modoinding was 71%.

Chili

Varietal preference of Aphis gossypii and Myzus persicae.

High populations of *Myzus persicae* were found on AVRDC chili pepper lines PP0543-139, PP0209-4 and PP97-7195-1 followed by local varieties Seta Super and Dewata F1. The lowest population was collected on PP9852-173 and PP0543-139

Higher populations of *Aphis gossypii* were found on PP0209-4, PP97-7195-1, Dewata F1 and Bara. The lowest populations were found on PP9852-173 and Seta Super.

Virus disease incidence in chili peppers

The highest percentage of infestation by viral disease was on PP0209-4 (63.8%) followed by Dewata F1 (62.8 %) and PP97-7195-1 (54.1 %). The lowest infestation was on PP0543-139 (37.5 %) and Bara (43 %).

Pseudomonas fluorescens from different soils in North Sulawesi

Some strains of *P. fluorescens* have been isolated from vegetable growing areas in Rurukan, Toure and Modoinding. These strains are being purified and identified for further characterization.

Papaya

Distribution of Paracoccus marginatus on papaya in North Sulawesi.

In August 2009, papaya trees in Manado were found infested by the papaya mealy bug, *P. marginatus*. Surveys conducted from April to September 2010 on papaya in North Minahasa, South Minahasa, Bolaang Mongondow, North Bolaang Mongondow, and West Bolaang Mongondow in North Sulawesi and found no papaya mealybug infestation.

FIELD/Indonesia, Medan, North Sumatera, Padang, West Sumatera

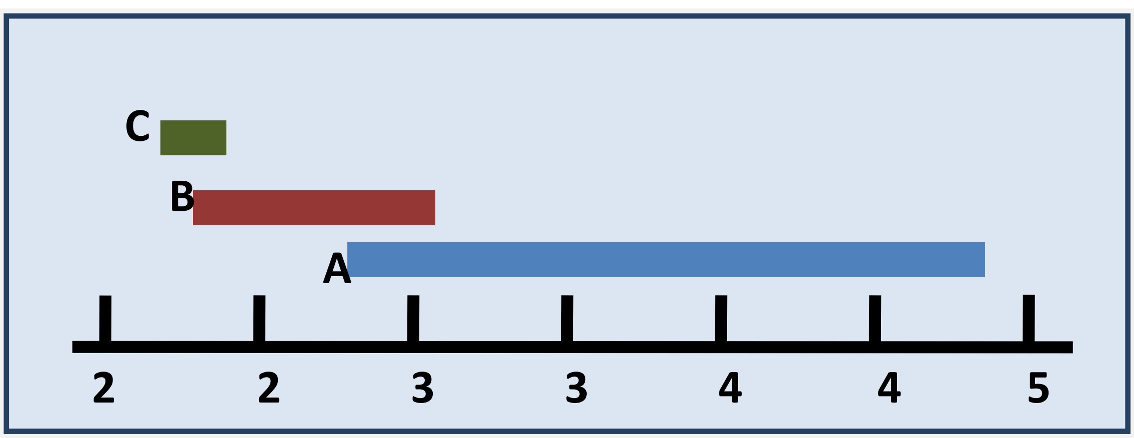
Cacao IPM Program

Formasi Pelita Kasih Farmers' Network of Sibolangit conducted a study in a cacao plantation with the following treatments.

A. compost + pruning
B. pruning only
C. control (no compost, no pruning)

The compost used for this study was prepared from mixture of: coconut water (20 liter), banana stem (10 kg), leaves (10 kg), durian rind (5 kg), goat manure (20 kg), wood sawing waste (20 kg) and kitchen waste (30 liter).

The result showed that treatment A (compost + pruning) gave significant increase in yield



Cacao yield in different treatments: Compost + Pruning (A); Pruning (B) and Control (C) compared to control, but not significantly different from treatment B (pruning only).

The use of compost and pruning technologies are being disseminated to other cacao farmers in Sibolangit area.

Philippines

Philippine Rice Research Institute - PhilRice

Eggplant, tomato, watermelon, melon, squash, bottle gourd

Development of vegetable disease diagnostic kit/tool for farmers

Vegetables are considered as cash crop in the rice-based cropping system. Diseases are limiting factors of the pre- and post-harvest production. There are about 57 diseases known attacking lowland vegetables. So far, we have identified 20 of them – 11 caused by fungi, 5 by bacteria, 6 by viruses, and 1 by nematode. Only common diseases of onion and tomato were fully reported and are published as field guide.

Availability of reliable and simple disease diagnostic kit is the key to help farmers in planning and deciding efficient disease management strategies. Quick and accurate plant disease diagnosis prior to taking action is the most efficient tool in disease management. Hence, this project aims to develop a simple and easy-to-use vegetable disease diagnostic kit/tool for farmers.

Simple diagnoses of common diseases of lowland vegetables were compiled based on vegetable crop, pathological types of the disease, disease symptoms, signs, disease onset and severity, and predisposing factors. All the diseases identified are presented in colored photos so that farmers can compare with the actual disease/diseases they encounter in their fields.

Development of biological control formulation for the management of soil-borne diseases

Bacterial biological control and root growth promoter and free-N fixing bacteria are indigenous resources in the rice-based vegetable cropping systems, yet they have not been explored and applied efficiently. Some isolates are collected and maintained at the Plant Pathology Laboratory of PhilRice.

Characterization of microbial bio-diversity associated with lowland vegetables is being done. This will identify rhizospheric and endophytic bacteria associated with rice-based vegetable farming systems. Hence, soil samples from different vegetable fields (chili, biter gourd, onion and winged bean) were taken and composited for isolation, identification and evaluation of their BCA potential.

Bacillus subtilis, B. pumilus, and *B. polymyxa*, *Streptomyces* spp. were commonly found in soil planted to the bitter gourd and winged bean. Biodiversity studies on the bacterial community in onion, bitter gourd and winged bean has been initiated. Assessment of growth plant hormonal bacteria isolates is also ongoing.

Initial in-vitro assay identified two isolates of *Bacillus subtilis* (C6 and E3) which are antagonistic against the fungal pathogen causing gummy stem blight of cucurbits and *Cladosporium* sp. of okra. Liquid and powdered forms of *Bacillus species* were initially produced for field trial against soil-borne pathogens of bitter gourd. Shelf-life of these bacterial preparations is about 6 months. Most of the liquid formulation had pH 5.6 which are compatible with the pH of the soil required for vegetable production.

Effective *Trichoderma* sp. and VAM have been identified and developed and now being promoted by the IPM CRSP/PL480 Projects. VAM besides its BCA property, also acts as biofertilizer. In a study conducted, using 780kg

VAM/ha costs P6,940. This is equivalent to the application of 130-108-84kg NPK/ha of inorganic fertilizer for onion costing P18,000 resulting in a savings of P11,060 or 61%.

Paeclomyces spp. for the management of whiteflies and thrips in vegetable crops

H. X. Truong, K. B. Pangilinan, H. R. Rapusas

The whitefly, *Bemisia* sp. is a serious pest of various vegetable crops. Farmers rely on the use of synthetic insecticides. However, this practice created pest resistance, hazard to the environment, and affect non-target organisms. Hence, the use of microbial agents is being explored in terms of identification of virulent and effective microorganisms, mass production of these organisms, and the safe and effective delivery system in the field.

Three species of beneficial fungi were identified (*Metarhizium anisopliae*, *Paecylomyces* spp., and *Beauveria bassiana*) to cause mortality of eggs and nymphs of the whitefly. However, *Paecilomyces* isolates were found most effective. Hence, collection of different isolates was continuously done resulting in 315 isolates collected. Of these, 160 were initially screened and 21 isolates showed potential for the management of this pest.

Currently suitable substrates for mass production are being identified for optimum fungal growth (spores/conidia) for the formulation. Further studies are being conducted to determine the right amount of spore concentration to be inoculated in the substrate, maximum days of incubation and proper drying of the substrate. Field testing on the effectiveness of *Paecilomyces* is being conducted.

Onion, bittergourd, chili pepper

Village level production and utilization of NPV in rice-vegetable cropping system

G. S. Arida, B. S. Punzal, B. M. Shepard

The high cost of insecticide inputs and its toxic effects to farmers and the environment is a big concern in vegetable production worldwide. Naturally-occurring beneficial organisms like NPV could be mass produced by farmers and use for several species of lepidopteran pests. Earlier studies showed that this organism could be mass produced and could be used by onion farmers with similar effect as synthetic insecticides for cutworm. Furthermore, several farmer cooperators successfully used NPV against the common cutworm, *Spodoptera litura* in onion.

A total of 118 (81 male and 37 female) vegetable farmers from four villages in Bayambang, Pangasinan attended demonstrations on the techniques in mass production and use of NPV from January to February 2010. Some farmers tried mass producing the organism themselves. The stock culture we used came from our culture maintained by the IPM CRSP group of the Crop Protection Division of PhilRice.

Onion, tomato, eggplant

Technology transfer, promotion and dissemination of pest management technologies

H. R. Rapusas, Ev Parac, Glenn Ilar, S. E. Santiago, J. M. Ramos

Implementation of IPM training programs on onion and other vegetables

Different types of trainings were conducted – Specialized training of trainers usually one week long (TOT), season-long training for farmers and agricultural technicians popularly known as farmers field school (FFS), a two-day intensive training composed mainly of lectures/

discussions, one-day technical briefings, specialized training (practicum- usually hands-on activities on specific activity or technology).

Farmers Field Schools (FFS).

There were 17 FFS conducted in different provinces and municipalities. Most of these were on IPM on onion, garlic, eggplant, tomato, bitter gourd and other vegetables. These were conducted mostly in Pangasinan, La Union, Ilocos Sur, Ilocos Norte, Nueva Vizcaya, and Nueva Ecija. We graduated 629 participants ranging from 20 to 60 participants from each site. Of these, 486 (77%) were males and 143 (23%) were females.

Farmers' trainings/briefings

These are usually a one-day or two-day activities. Nine farmers trainings/briefings were conducted in nine sites with a total of 302 participants. There were 219 (73%) male participants and 83 (27%) females. Four of these were conducted in Pangasinan, one each in Pampanga, Nueva Ecija, Nueva Vizcaya and two in Ilocos Sur.

Farmers' Field Days

Five farmers' field days were conducted during the year – Tomato field days in Catablan, Urdaneta City, Pangasinan and Sucsusquen, Piddig, Ilocos Norte, eggpalnt field days in Nalvo, Pasuquin, Ilocos Norte and Mulmulaan, Paoay, Ilocos Norte and an onion field day in Caranglaan, Alcala, Pangasinan. During the field days, farmers from other barangays were also invited.

Information Campaign (Oplan Sagip Sibuyas)

This information campaign was launched in Bayambang, Pangasinan (the highest onion producer of the province). This campaign supplemented the IPM activities after the launching. From the information gathered from baseline surveys and FGDs, The most serious problems of the onion growers are pests and diseases. The campaign aimed to increase/enhance rice-onion farmers' knowledge, attitude, and practice on the management of common insect pests and diseases which are causing major yield reduction in rice-onion farming system in the focus barangays.

During the launching, 401 farmers, extension workers, municipal and barangay officials, teachers, researchers, students/pupils and press people attended and participated. The launching was highlighted by a mini parade around the town.

After the launching, FFS and information caravans followed, campaign jingles produced, information materials produced and disseminated. Among the major activities of the campaign are media releases, information caravans, exhibits, farmers' field schools, distribution of extension materials like flyers, posters, bulletins, etc.

Campaign stories were also prepared and distributed to press people. Likewise, a blog site (http://OplanSagipSibuyas.wordpress.com/) is continuously maintained and regularly updated. IPM technologies were also made available on the Pinoy Farmers' Internet (http://www.OpenAcademy.ph/) under the vegetable category.

Village-level production, integration and implementation of VAM and *Tricboderma* sp.

H. R. Rapusas, S. E. Santiago. J. M. Ramos, M. B. Brown

As a result of the trainings or practicum on the mass production of VAM and *Trichoderma* sp., some groups of farmers (farmers' association/cooperatives) started mass producing the BCAs for a village-level or community-wide production and implementation of the technologies for different vegetable crops, onion, corn and even for tobacco in northern Philippines. These farmers realized the benefits of these BCAs in their vegetable production.

In the economic assessment conducted on the use of VAM and *Trichoderma* sp. their was an increase of 23% of the adopters over the non-adopters. There was also a reduction 46% and 19% on cost of fungicides and fertilizers, respectively in favor of the adopters. Analysis showed that farmers using both VAM and *Trichoderma* sp., the adopter/user had a net income averaging to P76,029.37/ha while the non-adopter/user had P26,179.05/ha resulting in an increase in net income of users by 169.56% over that of the non-users. This implies that the use of BCAs have contributed a lot in the reduction of production costs of users/adopters of the technologies.

Eighty percent (80%) of the sites where the practicum were conducted started mass producing the products at the village level.

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Tomato and Eggplant

Evaluation of new IPM technologies for IPM in tomato and eggplant:

For the IPM treatment, seedbed was prepared by adding 10 kg/ha of VAM (vesicular arbuscular mycorrhizae) to autoclaved garden soil. For the farmers' practice plots, no VAM was added to the seedbed. The experimental area was prepared with one plowing followed by two harrowings. Complete fertilizer (14-14-14 NPK) was applied basally prior to transplanting and urea (45-0-0 NPK) was side-dressed at 30 days after transplanting. Thirty-day old seedlings of tomato cultivar "Diamante" and of wild cherry tomato were transplanted on June 25, 2010 at a distance of one seedling for every 0.5 m^2, (approximately 20,000 seedlings per ha). Plants were irrigated as needed with a deep-well pump.

The treatments were 1) use of wild cherry tomato; 2) use of earwigs (*Euborellia annulata*; 20,000 earwigs/ha released at 7 and 14 WAT; 3) use of *Trichogramma chilonis* (six releases of 50 *Trichogramma* cards/release at 30, 34, 38, 42, 49, and 56 DAT); and 4) use of rice straw mulch (2.5 cm thick) applied at 7 DAT for weed control and to serve as refugia for the earwigs followed by two handweedings at 6 and 12 WAT.

The treatments for farmers' practice plots were 1) use of commercial cultivar 'Diamante': 2) weekly spraying of insecticide Selecron (profenofos, 1 L/ha) starting at 14 DAT; 3) weekly spraying of fungicide Dithane (mancozeb, 1 L/ha) starting at 14 DAT; 4) handweeding 7 times (2, 4, 6, 8, 10, 12 and 14 WAT).

Earwigs collected from borer-infested corn fields, were reared in the laboratory in acrylic pans (14.5 cm wide x 8.5 cm depth) containing 2-3 cm vermi-compost soil. A colony can be started with 5 acrylic pans, each containing 6 female and 3 male adult earwigs. The earwigs are fed with 1 tablespoon fry mash every 10 days. The females are allowed to lay 4 to 6 batches of eggs (40 eggs/batch) and eggs are allowed to hatch within 7 to 9 days. From the stock colony, 150 female and 50 male adult earwigs are placed inside a mass rearing box (37.5 cm x 73 cm x 28 cm) containing vermi-compost soil. The adults are fed with 400 g of fry mash initially, then with 200 g fry mash per box every 10 days. Additional cultures can be prepared by collecting the third instar nymph, placed in another acrylic pan with vermi-compost soil and fed until adulthood. At least 10 rearing boxes should be maintained for a 1-ha vegetable farm and should be set up 1.5 months ahead of planting date. The earwig adults are released twice, at 7 and 14 DAT, with two earwigs/m^2 or a total of 20,000 earwigs/ha. Continuous release of earwigs every cropping season is necessary to establish adequate earwig population in the vegetable

Table 1. Degree of weed, insect and disease infestation in tomato treated with IPM and Farmers' Practice in UPLB Central Experiment Station, June-October 2010

Treatment	Weed FW (g/m²)	Fruitworm % fruit damaged	Leafhopper % plant damaged	Leaf curl % plants damaged
Farmers' practice: cultivar 'Diamante'	183.5	37	25	100
IPM: wild cherry tomato	184.2	5	15	36
Reduction over Farmer's practice (%)	0	86	40	64

field. Mulching with rice straw at 7 DAT provides refugia for earwigs while preplanting cultural practices such as plowing and harrowing reduces earwig populations.

Treatments were replicated four times and laid out in a randomized complete block design. The degree of insect pest infestation (tomato fruitworm, leafhopper and whitefly) were recorded weekly and expressed as percent of fruits or plants damaged. The degree of disease infestation (tomato leaf curl virus) was recorded weekly and expressed as percent of plant or fruits damaged. Weed density (number/m²) and fresh weight (g/m²) by species were recorded at 4 WAT and at harvest.

Fruits were harvested starting from 45 to 115 days after transplanting Total yield (weights of marketable and non-marketable fruits) were recorded and yield expressed in t/ha. Cost of all crop protection and crop production inputs were recorded to estimate net profits obtained from the IPM treatments and were compared with those obtained from treatments with farmers' practices.

The wild cherry tomato showed two- to three-

Table 2. Fruit yield, crop value, pest control costs, total production costs and net profit in tomato treated with IPM and Farmers' Practice in UPLB Central Experiment Station, Laguna from June to October, 2010.

Treatment	Yield (t/ha)	Crop Value ($/ha)[1]	Weed Control Cost ($/ha)	Insect Control Cost ($/ha)	Disease Control Cost ($/ha)	Production cost ($/ha)	Net Profit[2] ($/ha)
Farmers' practice: cultivar 'Diamante'	6	4680	249	125	30	1, 140	3,540
IPM: wild cherry tomato	5	3900	115	47	8	871	3,029
Reduction over farmers practice (%)	16	16	54	62	73	24	14

[1] Farmgate price of tomato = Php 35/kg or $0.78/kg; $1 = Php45.00

[2] Total production cost – Pest control costs + other costs

Net profit: Crop value minus total production cost fold higher resistance to the tomato leaf curl virus, with 64% less incidence of the leaf curl virus compared with the commercial cultivar Diamante (Table 1). It also had higher resistance to insect pest infestation, with 86% lower infestation of fruitworm and 40% less infestation from leafhopper damage. Weeding treatments showed that three handweedings in the IPM plots provided adequate control, which was similar to control provided by seven handweedings in the farmers practice plots. This indicates that three handweedings is adequate for season-long weed control and that there is no need for seven handweedings throughout the season.

The cost of control from the IPM practices were also lower by 54% for weed control, 62% for insect control and 72% for disease control, resulting in total production costs which were 24% lower in the IPM plots than in the farmer's practice plots (Table 2). However, because the cherry tomato has small fruits compared to the commercial cultivar 'Diamante', it yielded 16 % lower marketable fruits than the commercial cultivar with a corresponding reduction of 14 % in net profits in the cherry tomato cultivar compared with 'Diamante'.

Thus, in spite of the 100% infestation from leaf curl virus, the cultivar Diamante still produced fruits, thus the lower crop protection costs incurred from using the wild cherry tomato cultivar was not able to compensate for its low yields, resulting in net profit which was 14% less than net profit obtained from using the commercial cultivar Diamante.

Eggplant

The study was conducted at the UPLB Central Experiment Station from June to October 2010.

Seedbed was prepared by adding 10 kg/ha of VAM (vesicular arbuscular mycorrhizae) to autoclaved garden soil for the IPM treatment. For the farmers' practice plots, no VAM was added to the seedbed.

A wild eggplant cultivar known to be resistant to bacterial wilt (*Ralstonia solanacearum*) was used as rootstock and grafted to a high yielding but bacterial wilt-susceptible commercial variety of eggplant, Dumaguete Long Purple (DLP). Seeds of the wild eggplant cultivar were sown 2 weeks ahead of Dumaguete Long Purple. (DLP germinates about 2 wks earlier than the wild eggplant cultivar). Twenty one day old seedlings of Dumaguete Long Purple (scion) and 40-day old seedlings of wild eggplant (root stock) were grafted. The wild eggplant cultivar was cut across the lower portion of the last node of the stem and the upper part of the shoot was discarded. The upper part of the shoot of DLP was cut wedge-shaped and inserted into the stem of the wild eggplant. Parafilm was wrapped around the cut stems to seal the grafted portion. The grafted seedlings were placed inside a moisture chamber for 1 to 2 weeks. To maintain moist condition inside the moisture chamber, water was hand-sprayed on the walls of the chamber about three to five times daily. The seedlings were placed under direct sunlight for 3 to 5 days for acclimation to field conditions.

Land preparation was done with one plowing and two harrowings. Complete fertilizer (14-14-14 NPK) was applied basally prior to planting and urea (45-0-0 NPK) was side-dressed at 30 days after transplanting. Sixty-day old seedlings of eggplant cultivar 'Dumaguete Long Purple' grafted with a wild eggplant cultivar and thirty day old non-grafted seedlings of commercial cultivar 'Dumaguete Long Purple' were transplanted on August 25, 2010 at a rate of one seedling per 0.5 m^2, (approximately 20,000 seedlings/ha). Plants were irrigated as needed with a deep-well pump and soil moisture maintained at field capacity. Fruits were harvested starting from 50 days after transplanting and still on-going.

The treatments for IPM plots were 1) use of commercial cultivar 'Dumaguete Long Purple' grafted with a wild eggplant cultivar as the rootstock; 2) use of earwigs (*Euborellia*

Table 3. Degree of weed, insect and disease infestation in eggplant treated with IPM and Farmers' Practice in UPLB Central Experiment Station, June-October 2010

Treatment	Weed fresh weight (g/m^2)	FSB (% fruit damaged)	Leafhopper (% plants damaged)	Bacterial wilt (% plants damaged)
Farmers' practice: non-grafted commercial cultivar 'DLP"	282	29	40	20
IPM: DLP grafted with wild eggplant	230	14	35	0
Reduction over Farmer's practice (%)	18	52	13	100

annulata; 20,000 earwigs/ha released at 7 and 14 WAT; 3) use of *Trichogramma chilonis* (six releases of 50 *Trichogramma* cards/release at 30, 34, 38, 42, 49, and 56 DAT; and 4) use of rice straw mulch (2.5 cm thick) applied at 7 DAT for weed control and to serve as refugia for the earwigs followed by two handweedings at 6 and 12 WAT.

The treatments for farmers' practice plots were 1) use of non-grafted commercial cultivar 'Dumaguete Long Puirple': 2) weekly spraying of insecticide Selecron (profenofos, 1 L/ha) starting at 14 DAT; 3) weekly spraying of fungicide Dithane (mancozeb, 1 L/ha) starting at 14 DAT; 4) handweeding 3 times (2, 4, and 6 WAT).

Preparation and use of earwigs was done in a manner similar to those used in the tomato study.

Treatments were replicated four times and laid out in a randomized complete block design. The degree of insect pest infestation (fruit and shoot borer, leafhopper) were recorded weekly and expressed as percent of fruits or plants damaged. The degree of disease infestation (bacterial wilt) was recorded weekly and expressed as percent of plant or fruits damaged. Weed density (number/m^2) and fresh weight (g/m^2) by species were recorded at 4 WAT and at harvest.

Fruits were harvested starting at 50 days after transplanting Total yield (weights of marketable and non-marketable fruits) were recorded and yield expressed in t/ha. Cost of all crop protection and crop production inputs were recorded to estimate net profits obtained from the IPM treatments and were compared with those obtained from treatments with farmers' practices.

Leafhopper infestation was 13% lower in the grafted seedlings than in the non-grafted seedlings (Table 3). Fruit and shoot borer infestation was also 52% lower in the grafted seedlings than in the non-grafted seedlings. The grafted seedlings also had zero bacterial wilt incidence, compared to 20% bacterial wilt incidence in the commercial cultivar Dumaguete Long Purple. In spite of only two handweedings in the IPM plots, weed infestation was 18% lower in these plots compared to the three handweedings in the farmer's practice plots, indicating that there is no need for three handweedings for adequate season-long weed control.

The cost of inputs for insect and weed control in the IPM plots were both 25% lower than in the farmer's practice plots (Table 4). However, use of grafted seedlings to reduce bacterial wilt infestation was about 30-fold more expensive than using non-grafted seedlings. Higher inputs incurred in producing grafted seedlings increased the total production costs by 1.2-fold,

Table 4. Fruit yield, crop value, pest control costs, total production costs and net profit in eggplant treated with IPM and Farmers' practice in UPLB Central Experiment Station, Laguna from June to October, 2010.

Treatment	Yield (t/ha)	Crop Value ($/ha)	Weed Control Cost ($/ha)	Insect Control Cost ($/ha)	Disease Control Cost ($/ha)	Producti on Cost[1] ($/ha)	Net Profit ($/ha)[2]
Farmers' practice: Non-grafted cultivar 'DLP"	1.9	1,045	106	63	15	1, 056	-11
IPM: DLP grafted with wild eggplant	2.5	1,375	79	47	452	1, 280	95
Reduction (or increase) over Farmer's practice (%)	24	24	25	25	(-96)	(-18)	(88)

[1]Total production cost = Pest control costs + other costs

[2]Net profit = Crop value minus total production costs; farmgate price of eggplant =25/kg or $0.55/kg; $1 = Php45.00

which was about 18% higher than total production costs when non-grafted seedlings were used.

Since harvesting of fruits has been done for only about two weeks, we obtained relatively low yields in all plots in both IPM and farmer's practice plots. Nevertheless, fruit yields and crop values from the IPM plots where grafted seedlings were used were both higher by 24% than those from the farmers' practice plots where non-grafted seedlings were used. This is presumably due to the lower weed, insect and disease infestation in the IPM plots, compared to higher pest infestation in the farmers' practice plots.

In the farmers' practice plots, inspite of the low expenses incurred in use of non-grafted seedlings, high input costs from three handweedings and from weekly spraying of insecticides was not enough to compensate for the low inputs incurred in disease control (non-grafted seedlings). Thus total production cost in the farmer's practice plots was higher than its crop value, resulting in negative net profits. In contrast, in spite of the high costs incurred in producing grafted seedlings in the IPM plots, higher fruit yields and crop values in these plots coupled with lower input costs incurred in weed and insect control resulting in lower total production costs and higher net profits than in the farmers' practice plots.

Thus, even if higher costs of grafting increased the total production costs in the IPM plots over those of the farmers' practice plots, higher crop yields due to lower pest infestation and lower costs incurred in insect and weed control resulted in higher yields, crop values and net profits in the IPM plots. In contrast, in the farmers' practice plots, lower cost of using non-grafted seedlings did not compensate for the higher weed control and insect control costs, resulting in total production costs which were higher than the crop values. Crop values were low due to low yields resulting from higher pest infestations in the farmer's practice plots. The overall result is negative net profits in the farmer's practice plots.

Dissemination of IPM CRSP technologies:

Monitoring of pest incidence and crop yields in Department of Agriculture *Gawad Kalinga Goodbye Gutom* vegetable plots treated with IPM CRSP technologies

The study was conducted at the UPLB Central Experiment Station at the *Gawad Kalinga* project Techno-Demo Area, from March to September 2010. The area was plowed once and harrowed twice. Twenty one day old seedlings of eggplant cultivar 'Dumaguete Long Purple' and tomato were transplanted into 10 m^2 raised plots (40,000 seedlings/ha) along with other vegetables (okra, bittergourd, tomato, bush sitao, pechay and kangkong) on March 2010. Organic fertilizer (vermicompost) was applied at 30, 60, 90 120 and 150 DAT at the rate of 20 kg/10m^2. Rice straw mulch (2.5 cm thick) was applied at 120 DAT on IPM treated plots to serve as refugia for earwigs and as weed management. To manage insects, earwigs (*Euborelia annulata*) were released at 120 and 127 DAT (20,000 earwigs/ha) followed by six releases of *Trichogramma* cards (50 Tricho cards per release) starting at 120, 124, 128, 132, 139, 146 DAT. Mechanical removal of plant parts damaged by insect pests and diseases was done starting at 120, 127, 134, 141 and 148 DAT. Insect and disease incidence was monitored at weekly intervals. Incidence of bacterial wilt and leaf curl was monitored in each plot at weekly intervals and expressed as percent of plant damaged. Weed density and fresh weights were recorded at 140 DAT. The incidence of fruit and shoot borer was expressed as percent of damaged fruits. The incidence of leafhopper was expressed as percentage damaged plants. Plants were irrigated as needed with a deep well pump and soil moisture maintained at field capacity. Eggplant and tomatoes were harvested starting from 45 to 180 days after transplanting.

Weed, insect and disease infestation in tomato and eggplant treated with IPM CRSP technologies consisting of use of natural enemies such as earwig and *Trichogramma* and cultural practices such as removal of damaged shoot and fruits due to bacterial wilt and leaf curl infection kept pest infestation at low levels; 27 to 35% in tomato and 25 to 42% in eggplant. These technologies also reduced input costs and cost the grower only $44/ha for weed and disease control and $47/ha for insect control. From using these technologies, the growers obtained fruit yields equivalent to 18 t/ha with a corresponding crop value of $14,040 for tomato and to 23 t/ha, with a corresponding crop value of $ 12,650 for eggplant.

For the past two years, IPM CRSP has provided technical assistance to the Department of Agriculture project known as *Gawad Kalinga* ("to give care") vegetable production project. The *Gawad Kalinga* project is a holistic community program that aims to eradicate poverty and hunger in the Philippines by providing housing and vegetable production activities to participating families, mostly from the urban poor.

Introduction of IPM CRSP technologies to the participants of the *Gawad Kalinga* project will help disseminate use of agro-ecological approaches such as use of natural enemies (earwig, *Trichogramma*), soil enhancement additives (VAM), and cultural practices (mulching, two timely handweedings for one cropping season, removal of infected plant parts) which are cost-reducing with minimum adverse effects on the environment. Low input costs from the IPM CRSP technologies will provide added benefits to growers in the form of higher net profits.

The *Gawad Kalinga* project is a nationwide project of the Department of Agriculture, and collaboration of IPM CRSP with the various GK sites, starting with the central and southern Luzon provinces, has the potential to provide a big impact on vegetable production in the country.

Cambodia

Establishment of a collaborative network in Cambodia to participate in the SE Asia regional program

Clemson scientists traveled to Cambodia with IPM CRSP Program Director and USAID AOTR to meet with potential collaborators in Cambodia and visit major production locations. The purpose of the trip was to identify Cambodian collaborators. It was decided that a collaboration with the National IPM Programme, in the General Directorate of Agriculture (GDA) of the Ministry of Agriculture, Forestry, and Fishery (MAFF) would be appropriate for the regional project. Several NGOs are active in Cambodia working in agriculture and rural development. IDE's program of Farm Business Advisors provides a useful network for extending IPM technologies to farmers.