Yield and Response of First and Ratoon Crops of Eggplant (*Solanum melongena*) to the Eggplant Fruit and Shoot Borer (*Leucinodes orbonalis*) under an Integrated Pest Management System

Cyrose Suzie C. Silvosa[1,*], Eufemio T. Rasco Jr.[1,2], Reynaldo G. Abad[1], Desiree M. Hautea[3], Jerby Anne M. Basilio[1], Melvin Al Joershon R. Esporsado[1], and Camille Faye S. Te[1]

[1] Department of Biological Sciences and Environmental Studies, College of Science and Mathematics, University of the Philippines Mindanao, Mintal, Tugbok District, Davao City 8022, Philippines.
[2] Philippine Rice Research Institute (PhilRice), Science City of Muñoz, Nueva Ecija 3119, Philippines.
[3] Institute of Plant Breeding, Crop Science Cluster, College of Agriculture, University of the Philippines Los Baños, College 4031, Laguna, Philippines.
[*] Corresponding author. Email: cs_silvosa@yahoo.com. Telephone: +63 82 293 0312 local 21.

Abstract

Eggplant (*Solanum melongena*) is a highly valued crop with an average production of 10 t·ha^{-1} and contributes to nearly PhP2 billion in the Philippine economy using conventional farming methods. An integrated pest management system was designed to control the eggplant fruit and shoot borer (EFSB) for increased productivity with reduction on harmful pesticide inputs. Under a split plot in randomized complete block design, two eggplant varieties, i.e., hybrid Banate King F1 (BK) and open-pollinated Dumaguete Long Purple (DLP), were tested under four different pesticide treatments, namely, (1) control–no pesticide, (2) organic–Bird's chilli extract, (3) synthetic–spinosad + flubendiamide, and (4) combination–Bird's chilli extract + spinosad + flubendiamide. After data was obtained, the first crops were ratooned and tested under the same IPM system. Data on yield and EFSB damage of the ratoon crops were compared with the first crop as influenced by eggplant variety and pesticide treatment. All plants were grown on plots covered with polyethylene mulch sheets under a uniform fertilization and fungicide regimen. Multiple cropping with regular field sanitation and inspection were also incorporated in the IPM system. Results indicate that BK is a superior variety over DLP with a gross yield of about 40 t·ha^{-1} and a marketable yield of about 20 t·ha^{-1} in 22 harvests. Ratoon crops produced lower yield than first crops with only 2 t·ha^{-1} in 12 harvests. Among the pesticide treatments, synthetic or combination treatments are superior over the control (no pesticide) or organic treatments. Use of open-pollinated DLP and chilli spray is inferior to hybrid and synthetic or combination sprays. Chilli spray also tends to nullify the effectiveness of synthetic pesticides when used in combination. The designed IPM system produced higher yield than conventional methods, but all treatments only provided moderate control over EFSB damage with average yield losses of about 50% in first crops and about 60% in ratoon crops.

Keywords: chilli; flubendiamide; integrated pest management; *Leucinodes orbonalis*; *Solanum melongena*; spinosad

Abbreviations:

ANOVA – analysis of variance
BK – Banate King
DLP – Dumaguete Long Purple
EFSB – eggplant fruit and shoot borer
IPM – integrated pest management
RCBD – randomized complete block design

Introduction

Eggplant (*Solanum melongena*) is a herbaceous plant that can be grown in lowland farms and those found in altitudes of 1200 m above sea level. It produces round to elongated fruits that are white to dark purple with a length of 4 to 45 cm and width of 2 to 35 cm and fruit weight ranging from 15 to 1500 g (Swarup, 1995). It may be cultivated up to two years (FAO, 1993–2007). Kashyap et al. (2003) notes that Asia is the highest producer of eggplants (20.6 million mt) worldwide. In the Philippines, eggplant is one of the major vegetable crops (Briones, 2009). As of 2003, eggplant production contributed PhP1.8 billion to the Philippine economy (Francisco, 2009), with an average production of 9.95 $t{\cdot}ha^{-1}$ (Vijayraghavan, 2010). At the provincial level, the Davao Region, one of the top eggplant producers, contributed a total of 6.6 mt in 2010 (BAS, 2010).

Banate King F1 is one of the preferred hybrid eggplant varieties in Davao City. It has moderate purple cylindrical fruits and was bred for the Mindanao market (Panergayo et al., 2008). Among open-pollinated varieties, eggplants with cylindrical fruits like the light purple Señorita (BPI, 2008) and long purple varieties such as Dumaguete Long Purple (Librero and Rola, 2000) seem to be the popular choices for cultivation.

In terms of cultural practice, modern farmers already replant at 6 months after the first harvest because of observed decline in yield as plants age yet traditional farmers still practice ratooning of eggplants (J. Tirando, 2011, pers. comm.). When ratooning, the plant crop is cut back and allowed to regrow for a short time to achieve a subsequent crop (Kahn, 2001). Although many studies have been conducted on ratoon crops, no recent publication on yield of ratooned eggplants was found. Also, yield of eggplant farmers is highly affected by pests such as leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer, blister beetle, red spider mite, and little leaf disease (Srinivasan, 2009). However, the eggplant fruit and shoot borer (EFSB) was found to be most destructive and causes up to 70% yield reduction (Alam et al., 2003).

Conventionally, growers had to rely on chemical pest control to achieve high marketable yield, which poses threats to environment and human health (Srinivasan, 2009; Chupungco et al., 2011). Eggplant farmers in Mindanao use three popular insecticides, namely, KARATE® (lambda-cyhalothrin), SUCCESS® (spinosad), and PREVATHON® (chlorantraniliprole) (R. Boclaras, 2011, pers. comm.; E. Micabalo, 2011, pers. comm.; J. Salming, 2011, pers. comm.). As reports of pest resistance emerged, companies produced better and safer pesticides. One of the new generation pesticides is spinosad, which is derived from an actinomycete, *Saccharopolyspora spinosa*. It is currently used as a grain protectant and pesticide for lepidopterans in crops such as eggplant (Mertz and Yao, 1990). Spinosad has low toxicity on mammals and considered a natural product that can be used in organic agriculture (Racke, 2007). Another novel pesticide is flubendiamide. It is a systemic synthetic pesticide that generally protects the plant by decreasing the feeding rate of larvae. It has a specific toxicity to lepidopterans, and reports show low toxicity in mammals and low risk to nontarget organisms (Lahm et al., 2009).

Because of the risks attributed with synthetic pesticides, botanical pesticides are now becoming popular. Botanical pesticides, derived from plants, are often slow-acting protectants, with minimal residues in the environment. Furthermore, because of variations in plant substances, there is no known resistance in pests or pathogens to botanical pesticides (Isman, 2006). Several plants can be used as botanical pesticides. However, two plants, chilli and neem, seem to be widely used against EFSB. Unfortunately, neem or neem extract is not readily available in Davao City unlike chilli. Chilli (*Capsicum* sp.) is a shrub from the Solanaceae family and is known for its pungency and hot flavor because of capsaicinoids (Collins and Bosland, 1994). Capsaicin, the active ingredient in chilli, is an animal repellent and it is registered as an insecticide, miticide, rodenticide, and feeding depressant, which could be used on crops and trees. Its mode of action on insects is through metabolic disruption, membrane damage, and nervous system dysfunction. Similar mode of action is expected even on nontarget organisms, making it toxic to honeybees and other beneficial insects (NPIC, n.d.).

Farmers spend as much as 14.2% of their capital on pesticides (Briones, 2009) to combat EFSB. Because of the costs in current practices, it is important to find alternative solutions. An integrated pest management (IPM) system is needed as a new approach to control EFSB damage. The aim of IPM is to reduce pest populations to avoid damage levels that cause yield loss. The initial approach to IPM is usually through focusing on the reduction of pesticide use. However, crop management decisions are best done when there is an understanding of the ecosystems. This includes understanding pests and the surrounding environment that could lead to healthy crops (FAO, 2003). Methods such as mechanical control and manual sanitation could be incorporated in an IPM package as part of prevention, but these methods are usually coupled with biological control agents and pesticides, whether botanical or chemical.

The current study was conducted to determine represented arthropod families in the site for assessment of diversity under the designed IPM system and to evaluate IPM components (eggplant variety and pesticide treatment) against the eggplant fruit and shoot borer (EFSB) on first crop and ratooned eggplants. Specifically, the study aimed to compare the two eggplant varieties—Banate King F1 (BK) and Dumaguete Long Purple (DLP)—in terms of fruit characteristics, number of fruits per kilogram, yield (gross, marketable, and cumulative), and resistance against EFSB, as well as to evaluate the use of spinosad + flubendiamide and hot chilli sprays for control of EFSB.

Materials and Methods

Establishing the Experimental Field

The experimental site was in the campus of the University of the Philippines Mindanao in Mintal, Tugbok District, Davao City (Figure 1). The experiment, divided into two parts based on the type of crops used, was conducted under a split plot in randomized complete block design (RCBD) with 5 replicates and 40 plants per replicate (Table 1). Banate King F1 eggplant variety served as border plants for the experiment. There were four replicates with half of the row planted with BK and the other with DLP.

Seeds of Banate King F1 (BK) and Dumaguete Long Purple (DLP) eggplant varieties were allowed to germinate in a sterile sowing medium of 1:1:1 charcoaled rice hull, garden soil, and compost. The mix was steam sterilized for at least 4 h and cooled down. Sterile mix was placed in seedling trays where sown seeds were allowed to grow in the greenhouse until ready for transplanting.

The first part of the experiment began on March 2011 when eggplant seedlings were transplanted to the field. Trials were managed based on the Recommended Guidelines for National Cooperative Trials of Vegetables by the Bureau of Plant Industry of the Department of Agriculture (BPI-DA, n.d.) and based on previously learned techniques on eggplant cultivation.

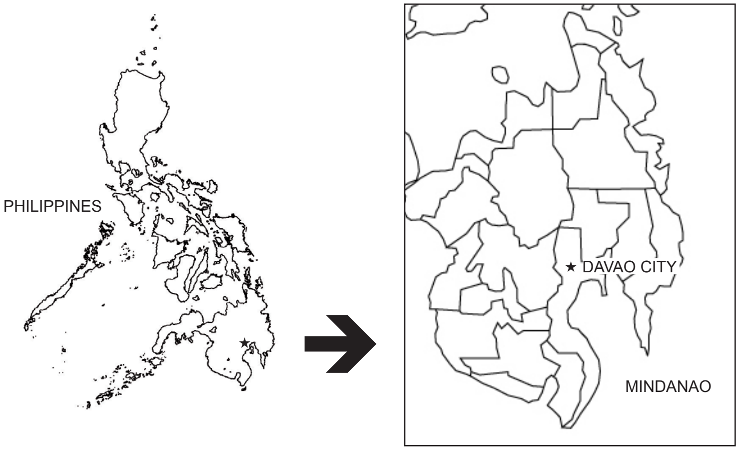

Figure 1. Map showing the location of Davao City, Philippines

All synthetic pesticides (SUCCESS® and FENOS®) were prepared based on recommended dosage and method written on the label. A 5-mL spreader sticker was added for every 16-L mixture of synthetic pesticide and was thoroughly mixed in a knapsack sprayer (SA-17 Tung Ho Golden Agin Sprayer) and evenly sprayed on each plant in the treatment plots. For the chilli spray, 50 g of fresh red Bird's chilli was blended with 50 mL of tap water for 1 min at no. 3 speed in an Osterizer® 10-speed blender. Additional 150 mL of tap water was added to the chilli mixture and was further blended at no. 5 speed for 6 min. After blending, the mixture was filtered through a 0.5-mm sieve and directly poured into a knapsack sprayer and diluted with 16 L of water. The mix was sprayed on each plant in the treatment plots. All controls and border plants did not have any pesticide treatment. Frequency of application was based on a 5% damage threshold level, wherein a minimum of 32 plants per variety were damaged by insects.

After the first part of the experiment was completed, shoots of existing 6-month-old eggplants were chopped off until 0.3 m of the main trunk was left. All plants were given complete basal fertilizer, and lateral shoots were allowed to fully develop.

Both basal and foliar fertilizers were applied on the ratooned eggplants. Addition of basal complete fertilizer (NPK 14:14:14) was done monthly. Foliar fertilizer, however, was applied weekly since frequent rain showers leached the basal fertilizer. Fungicides (ALIETTE® and DITHANE®) were prepared in the dosage and method written on the label. A 5-mL spreader sticker was added for every 16-L mix. The mixture of fungicide and spreader sticker was thoroughly mixed in a knapsack sprayer and evenly sprayed on each plant.

Table 1. Experimental details of the integrated pest management (IPM) experiment in Davao City, Philippines

Particulars	Part 1: IPM on eggplant fruit and shoot borer using eggplant crops	Part 2: IPM on eggplant fruit and shoot borer using ratooned eggplant crops
Treatment/Entries	Total: 8 Eggplant varieties: • OPV Dumaguete Long Purple • Hybrid Banate King F1 Pest control treatments: • T1: no EFSB control • T2: organic (chilli spray) • T3: synthetic/conventional (spinosad + flubendiamide) • T4: combination (chilli + spinosad + flubendiamide)	Total: 8 Eggplant varieties: • OPV Dumaguete Long Purple • Hybrid Banate King F1 Pest control treatments: • T1: no EFSB control • T2: organic (chilli spray) • T3: synthetic/conventional (spinosad + flubendiamide) • T4: combination (chilli + spinosad + flubendiamide)
Experimental design	Split-plot in randomized complete block design (RCBD)	Split-plot in randomized complete block design (RCBD)
Number of replications	4 per treatment	4 per treatment
Number of rows per treatment	4 rows	4 rows
Row-row spacing	1 m	1 m
Spacing between hills	0.75 m	0.75 m
Plot size of each treatment	30 m^2 each	30 m^2 each
Plants per treatment	40 (10 plants per row)	40 (10 plants per row)
Net experimental plot area*	960 m^2	960 m^2
Properties of border plants†	1 m between rows 0.75 m between plants	1 m between rows 0.75 m between plants

Notes:
* Plot size × number of treatments × number of replications
† Five rows of plants all over the perimeter of the net experimental plot area

Frequency of fungicide application was as needed but not more than the recommended rate.

First harvest of the first crops was in April 2011 and last (22nd) harvest was in July 2011. Ratooning for the second part of the experiment began days after the last harvest. Last harvest for ratooned eggplant was in 31 October 2011. The field was cleared after the experiment.

Data Collection and Analysis

Data was taken from 16 plants from the two inner rows of each plot per treatment that were tagged and numbered. These same plants were used in all observation periods throughout the crop duration. All harvested fruits per plot were brought to a shed and sorted according to the categories described below.

Category 1: Marketable
Class A (healthy): straight, blemished/unblemished, without EFSB holes
Class B (healthy): slightly curved, without EFSB holes

Category 2: Nonmarketable but without EFSB damage
Class D (healthy): crooked, without EFSB holes

Category 3: Nonmarketable with EFSB damage
Class C (damaged): straight, blemished/unblemished, with EFSB holes
Class E (damaged): not harvestable (very small, early EFSB damaged fruits), with EFSB holes

Weight of marketable fruits per plot was also recorded and totals of weight and number of all marketable fruits harvested from 16 plants in the two inner rows were calculated at end of the season. Equivalent marketable plot yield and hectare yield in tons per hectare were estimated based on a population of 13,333 plants per hectare.

For the first part of the experiment, fruit length and diameter (cm), number of fruits per kilogram at 3rd harvest, and hectare yield in $t \cdot ha^{-1}$ (gross yield, percent marketable yield, and cumulative yield) of the first crops were the collected. For the second part, number of fruits per kilogram and hectare yield in $t \cdot ha^{-1}$ (gross yield, percent marketable yield, and cumulative yield) of ratooned crops were collected.

Fruits ready for harvesting were picked every 4 d. Fruits were collected until 22 harvests in the first crop, and fruits in each harvest were sorted based on the 3 categories and classes described previously. For ratooned crops, fruits were collected until 12 harvests, and fruits in each harvest were sorted based only on the 3 categories. The fruits were counted and weighed to obtain the percent of damaged fruits based on weight.

For the IPM on two eggplant varieties, randomized complete block with variety as main plot and IPM treatments as subplots was used. Descriptive statistics and analysis of variance (ANOVA) of split-plot design was used for factorial analysis with 95% level of confidence using CropStat 7.2 (IRRI, 2009).

Results and Discussion

Arthropod Diversity under the Designed IPM System

Planting other vegetables within the experimental site helps decrease damage to the main crops because these may be intercropped to serve as repellents or alternate host of pests. Tomatoes, for example, serve as trap plants as they also become hosts of fruit borers (Cabrera et al., 2001) and thrips (Cabrera-Asencio, 1998) while sweet basil was found to contain essential oils that serve as acaricide (Refaat et al., 2002; Momen and Amer, 2003). Also, these plots serve as demo plots that show which crops may be used in rotation or intercropped with eggplants. The study noted the arthropods attracted by the other vegetables (Table 2).

Arthropod sampling revealed a variety of insects that live within the experimental site. Furthermore, a diverse population of arthropods were found within the site, and when sorted, 8 arthropod orders were found: Aranea, Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, and Orthoptera (Table 3). The diversification of agricultural crops is important to prevent infestation of one species of pests (Hooks and Johnson, 2003; Andow, 1991). Diversity of the arthropods in the site benefitted the crops since some arthropods are pollinators and others serve as biological controls that prevented the rise of other pests (Table 3). Ecological roles and the relationship of these arthropods to the EFSB in the eggplant site are still being assessed.

Experiment I: IPM on EFSB using First Crops

Variety Evaluation: Banate King F1 vs Dumaguete Long Purple

Popular hybrid varieties of eggplant in Davao City include the newly introduced hybrid variety Banate King F1 (BK), which produces long (25–28 cm), moderate purple, and cylindrical fruits (Panergayo et al., 2008), and the open-pollinated variety Dumaguete Long Purple (DLP), which produces about 24-cm-long purple cylindrical fruits (Librero and Rola, 2000).

Eggplant fruit length and diameter (cm). Significant differences were obtained between varieties and the interaction between variety and treatment in the fruit length parameter. BK fruits were longer than DLP with about 7 cm

Table 2. List of observed arthropods found on other vegetables in the experimental field

Crop	Scientific name	Dominant arthropod	Other arthropods
Bell pepper	*Capsicum annuum*	Ants	Flea beetle
Bitter gourd	*Momordica charantia*	Fruit flies	Spiders, beetle
Cucumber	*Cucumis sativus*	Beetles	Aphids
Chilli	*Capsicum frutescens*	Ants	Aphids
Kangkong (upland)	*Ipomoea reptans*	Leaf cutters	Mites
Lemongrass	*Cymbopogon citratus*	Aphids	Ants
Okra	*Abemochus esculentus* L. Moench	Ants	Metallic flies
Pechay	*Brassica rapa* var. Chinensis	Leaf cutters	Mites, ants
Pumpkin	*Cucurbita maxima* Duchesne ex Lamk	Beetles	Aphids
Smooth loofah	*Luffa cylindrica*	Bees	Mites, beetles
Sweet basil	*Ocimum basilicum*	Bees	Ants
Tomatoes	*Lycopersicum esculentum* Miller.	Dung flies, cutworms	Spiders, beetles, borers
Yardlong beans	*Vigna unguiculata* (L.) Walp.	Ants, aphids	Weevils

difference (Table 4). When the diameter of the fruits was compared, significant differences were found between varieties and among pesticides, but none on the interaction between variety and treatment. It was found that DLP fruits are wider than BK by about 0.5 cm. Among the pesticide treatments, the synthetic treatment (spinosad + flubendiamide) had fruits with the least width compared with the others (Table 5). While DLP was expected to reach longer fruit lengths, the incidence of mites as well as the environmental conditions in the IPM field perhaps did not meet the requirements of the open-pollinated DLP, resulting in shorter fruits.

Marketable fruits per kilogram. Relative size of the fruit can be measured by obtaining the number of fruits per kilogram in each variety. When comparing the fruit counts per kilogram between the two varieties and among the four pesticide treatments, lowest fruit count was on the initial harvest (1st and 2nd harvest) and highest was on the 11th harvest (Figures 2 and 3). By 12th to 22nd harvests, fruit counts were about 12 fruits per kilogram for both BK and DLP varieties (Figure 2). This was probably caused by the spraying of

Table 3. List of arthropod families found within the eggplant experimental site

Order	Some ecological importance	Represented families
Aranea (spiders)	Population control for Homoptera, Diptera, and Orthoptera, especially grasshoppers (Nyffeler et al., 1994; Nyffeler and Benz, 1987; Riechert and Bishop, 1990; Riechert and Lawrence, 1997; Young and Edwards, 1990)	Unidentified
Coleoptera (beetles, weevils)	Predators, decomposers, and herbivores (Petersen and Luxton, 1982; Rainio and Niemela, 2003)	Carabidae Chrysomelidae Coccinellidae Curculionidae
Diptera (flies)	Pollinators (adults) and biocontrol agents (larva) (Ssymank et al., 2008; Borkent and Harder, 2007)	Dolichopodidae Muscidae Otitidae Sarcophagidae Sphaeroceridae Ulidiidae
Hemiptera (bugs)	Ecological and environmental indicators (Moir and Brennan, 2007; Musolin, 2007)	Miridae Pyrrhocoridae
Homoptera (sucking insects)	Important pest—cause of crop damage (Quiroga et al., 1991)	Aleyrodidae Aphidoidea Cicadellidae Delphacidae Flatidae Pseudococcidae
Hymenoptera (wasps, bees, ants)	Predators of pests, biological control agents, pollinators, agents of soil improvement and nutrient cycling (Way and Khoo, 1992; Gotwald, 1986)	Encyrtidae Formicidae
Lepidoptera (butterflies, moths)	Important pest—cause of crop damage (Kumar, 1997; Alam et al., 2003; Anil and Sharma, 2010; Marino et al., 2006), biocontrol agents (Hoffmann et al., 1998)	Crambidae Lymantridae Noctuidae (Cutworm, Semilooper)
Orthoptera (grasshoppers, crickets, locusts)	Important pest—cause of crop damage (MacVean and Capinera, 1992), biocontrol agent (Bownes et al., 2010), ecological and environmental indicator (Báldi and Kisbenedek, 1997)	Acrididae Gryllidae Other arthropods are still for identification

Table 4. Mean length (cm) of eggplant fruits from Banate King (BK) and Dumaguete Long Purple (DLP) varieties under four pesticide treatments taken at third harvest of first crop

Pesticide treatment	BK*	DLP*	Mean
Treatment 1: no EFSB control	26.10	18.13	22.12
Treatment 2: organic (chilli spray)	25.18	17.77	21.47
Treatment 3: synthetic/conventional (spinosad + flubendiamide)	24.27	19.93	22.10
Treatment 4: combination (chilli spray + spinosad + flubendiamide)	25.57	19.41	22.49
Mean*	25.28	18.81	22.04
p-value (variety)		0.0018 (5% LSD: 2.167)	
p-value (pesticide treatment)		0.0906 (5% LSD: 0.797)	
p-value (pesticide treatment × variety)		0.0001 (5% LSD: 1.128)	

* Means between columns are significantly different at 95% confidence level.

Table 5. Mean diameter (cm) of eggplant fruits from Banate King (BK) and Dumaguete Long Purple (DLP) varieties under four pesticide treatments taken at third harvest of first crop

Pesticide treatment	BK*	DLP*	Mean
Treatment 1: no EFSB control	4.37	5.00	4.69
Treatment 2: organic (chilli spray)	4.49	4.86	4.67
Treatment 3: synthetic/conventional (spinosad + flubendiamide)	4.29	4.77	4.53
Treatment 4: combination (chilli spray + spinosad + flubendiamide)	4.46	4.87	4.66
Mean	4.40	4.87	4.64
p-value (variety)		0.0005 (5% LSD: 0.109)	
p-value (pesticide treatment)		0.0346 (5% LSD: 0.120)	
p-value (pesticide treatment × variety)		0.1466 (5% LSD: 0.170)	

* Means between columns are significantly different at 95% confidence level.

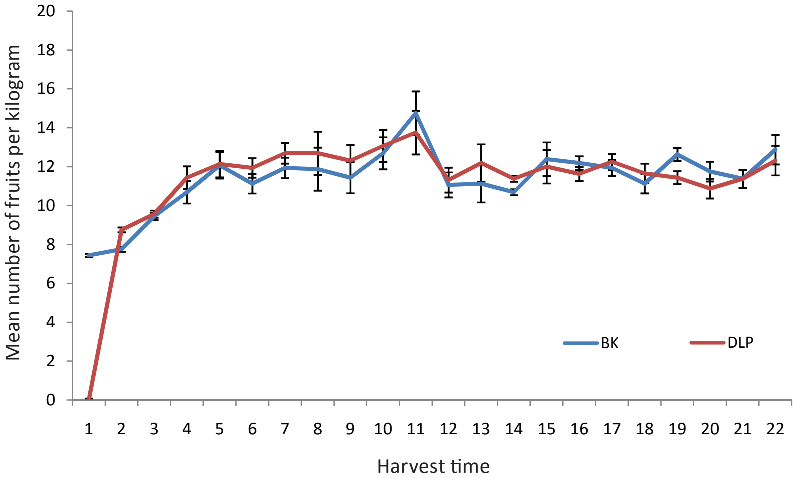

Figure 2. Comparison between Banate King F1 (BK) and Dumaguete Long Purple (DLP) marketable eggplant fruits per kilogram for 22 harvests

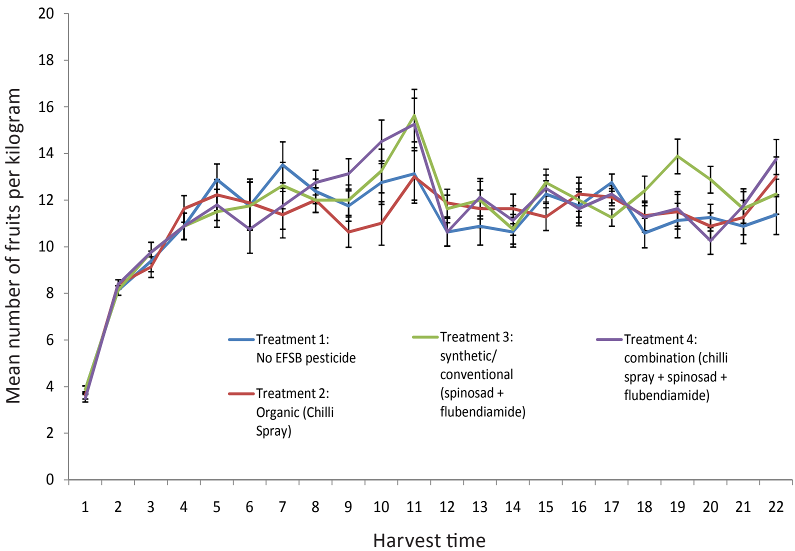

Figure 3. Mean number of fruits per kilogram of marketable fruits under 4 pesticide treatments against the eggplant fruit and shoot borer (EFSB)

liquid fertilizer on all plants, which was started during this time when the area was constantly flooded or served as a waterway for rainwater. By the final harvest, the combination treatment (chilli spray + spinosad + flubendiamide) seemed to have the highest fruit count while the control had the lowest count (Figure 3). When analyzing fruit counts in each harvesttime and considering only variety and pesticide as factors, there were no significant differences in fruit counts in the 3rd and last (22nd) harvests.

However, when harvest was included as a factor for the fruit count per kilogram, there were significant differences found, especially on the interaction between eggplant varieties, pesticide treatments, and harvesttime. Apparently, when the two harvest dates were compared, fruits obtained during the last harvest had significantly higher count over the 3rd harvest. Furthermore, highest fruit count was from BK variety under the combination treatment on the last harvest while least fruit count was from DLP variety under the organic treatment (chilli spray) on the 3rd harvest (Table 6). At this time, however, the fruit sizes were not measured individually, so the size can only be extrapolated from the corresponding number of fruits per 1 kg. Thus, higher fruit count per kilogram means smaller fruits. Interestingly, eggplant farmers in Digos City, Davao del Sur, observed decrease in size and opted to replant after two months since the 1st harvest (J. Tirando, 2011, pers. comm.).

Straightness of fruits. Photographs of representative fruits were obtained from the two varieties to assess the straightness of the fruits. Both varieties were observed to curve towards the end with more curved fruits in BK than in DLP.

Resistance of variety against EFSB based on yield. Even with an overall package, which included field sanitation, agricultural diversification, and alternative botanical pesticides, EFSB damages could still total to more than 10 $t \cdot ha^{-1}$ for both BK and DLP varieties. If physical damages and fungal infections are included in the counting, about 20 $t \cdot ha^{-1}$ was lost from the gross yield as nonmarketable fruits. Since BK has higher yield than its DLP counterpart, it also has higher volume of nonmarketable fruits. Nonmarketable yield tends to increase as gross yield increases and EFSB damage tends to increase through time (Figure 4).

IPM against EFSP

Marketable fruits per kilogram as influenced by treatments. For both 1st and last (22nd) harvests, no significant differences on the number of marketable fruits per kilogram were found. The trend in the data seems to suggest that there are about 10 fruits per kilogram on 3rd harvest and about 13 fruits per kilogram in the last harvest.

Table 6. Fruit counts per 1 kg of marketable eggplant fruits obtained on 3rd and 22nd (last) harvests from Banate King (BK) and Dumaguete Long Purple (DLP) varieties under four pesticide treatments

Pesticide treatment	3rd harvest		22nd (last) harvest	
	BK	DLP	BK	DLP
Treatment 1: no EFSB control	9.50	9.25	11.25	11.50
Treatment 2: organic (chilli spray)	9.50	8.75	11.50	14.50
Treatment 3: synthetic/conventional (spinosad + flubendiamide)	9.25	10.25	13.50	11.00
Treatment 4: combination (chilli spray + spinosad + flubendiamide)	9.50	10.00	15.25	12.25
Mean*	9.50		12.59	
p-value (pesticide treatment)	0.3154			
p-value (variety)	0.6736			
p-value (harvest time)	0.0000 (5% LSD: 1.027)			
p-value (variety × pesticide treatment)	0.3921			
p-value (variety × harvest time)	0.5111			
p-value (pesticide treatment × harvest time)	0.4244			
p-value (variety × pesticide treatment × harvest time)	0.0414 (5% LSD: 2.904)			

* Means between columns are significantly different at 95% confidence level.

Hectare yield. Average yield of eggplant produced over 22 harvests in the IPM field was 40 $t{\cdot}ha^{-1}$. This is higher compared with yield reports that put the average at 18 $t{\cdot}ha^{-1}$ (Doganlar et al., 2002b; Doganlar et al., 2002a). No significant difference was observed between the gross yields of the two varieties. Among the four pesticide treatments, higher yield was significantly observed under synthetic and combination treatments. There was no significant difference between the control and the organic treatments, and both are inferior compared with the synthetic or combination treatments. It seemed like chilli caused a decline in yield when it was used in combination with the synthetic pesticides (Table 7).

Actual marketable yield was significantly different between varieties and among the treatments. BK hybrid variety has a significantly higher marketable yield compared with open-pollinated DLP. Marketable yield was significantly higher in synthetic and combination treatments with about 5% difference with the control and organic treatments. There was no significant difference between

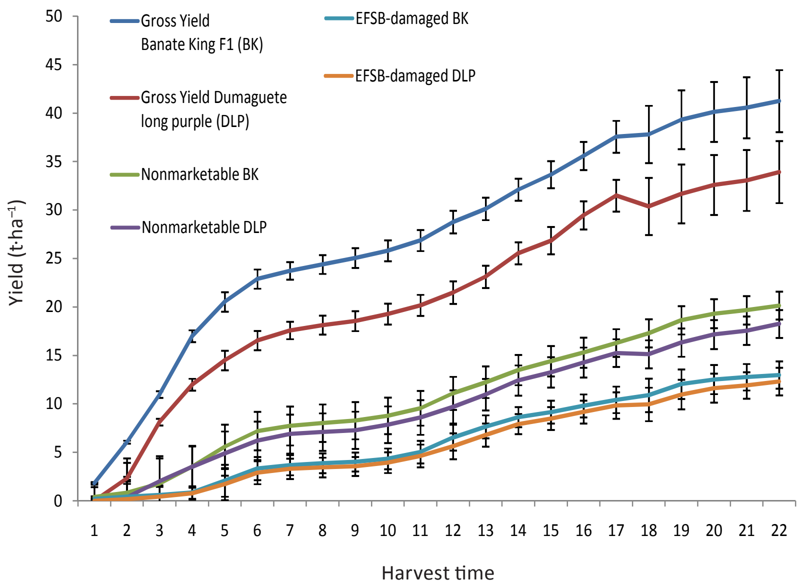

Figure 4. Cumulative gross, nonmarketable, and eggplant fruit and shoot borer (EFSB)–damaged fruits between Banate King (BK) and Dumaguete Long Purple (DLP) varieties (±SE)

Table 7. Gross weight ($t{\cdot}ha^{-1}$) of harvested eggplant fruits between Banate King F1 (BK) and Dumaguete Long Purple (DLP) varieties under 4 pesticide treatments

Pesticide treatment	BK	DLP	Mean[2]
Treatment 1: no EFSB control	36.82	34.01	35.41[b]
Treatment 2: organic (chilli spray)	40.17	31.93	36.05[b]
Treatment 3: synthetic/conventional (spinosad + flubendiamide)	47.42	44.16	45.79[a]
Treatment 4: combination (chilli spray + spinosad + flubendiamide)	45.85	39.43	42.64[a]
Mean[1]	42.56	37.38	

Notes:

[1] Means between columns are not significantly different at 95% confidence level (variety *p* = 0.102, 5% LSD = 7.06)

[2] Means within column with common letters are not significantly different (5% LSD = 4.20)

the control and the organic treatment, and both were inferior compared with the synthetic or combination. It seemed like chilli caused a decline in yield when it was used in combination with the synthetic pesticides (Table 8).

Yield of EFSB-infested fruits was compared against the gross yield of eggplant fruits. Among the treatments, it seemed like the highest gross yield by the last harvest was obtained from the synthetic pesticide treatment while lowest gross yield was from the organic treatment (Figure 5). It was also observed that EFSB-infested yield was in a close range among the four treatments and seemed to be relatively proportional to the gross yield (Figure 6).

The synthetic pesticides treatment was found superior over the control and organic treatments against EFSB. In a similar study conducted in India, results show that the synthetic treatments resulted to higher yield over the untreated eggplant control, with spinosad as the most effective treatment resulting to the least fruit and shoot infestation, followed by indoxacarb and emamectin benzoate (Patra et al., 2009). In Bangladesh, the use of flubendiamide and carbosulfan were best in protecting the eggplants from *L. orbonalis* based on laboratory and field trials (Latif et al., 2010), and the researchers even recommended including the application of flubendiamide at 5% level of fruit infestation as part of an IPM package (Latif et al., 2009). In another study on eggplants, flubendiamide used at 90 and 72 g ai/ha were the best treatments in reducing EFSB damage (Jagginavar et al., 2009). It seems that in this study, the tandem of spinosad and flubendiamide, which has specificity towards the control of lepidopterans, helped reduce EFSB population and resulted to higher marketable yield over the control and organic treatments (Table 8).

Table 8. Percentage of actual marketable yield of harvested eggplant fruits between Banate King F1 (BK) and Dumaguete Long Purple (DLP) varieties under four pesticide treatments

Pesticide treatment	BK	DLP	Mean[2]
Treatment 1: no EFSB control	51.88	43.33	47.61[b]
Treatment 2: organic (chilli spray)	48.20	43.56	45.88[b]
Treatment 3: synthetic/conventional (spinosad + flubendiamide)	53.89	50.48	52.18[a]
Treatment 4: combination (chilli spray + spinosad + flubendiamide)	54.86	46.16	50.51[a]
Mean[1]	52.21	45.88	

Notes:

[1] Means between columns are significantly different at 95% confidence level (variety p = 0.001, 5% LSD = 1.51)

[2] Means within column with common letters are not significantly different (pesticide treatment p = 0.020, 5% LSD = 4.10)

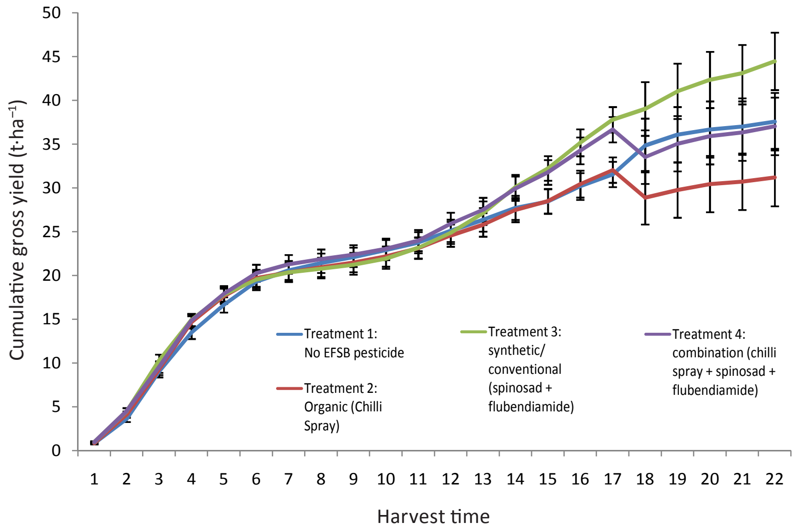

Figure 5. Cumulative gross yield of eggplants under 4 pesticide treatments against the eggplant fruit and shoot borer (EFSB) (±SE)

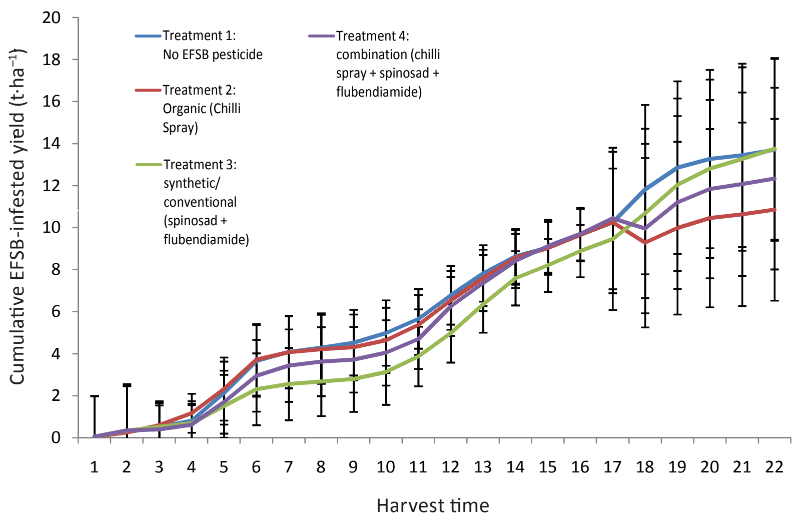

Figure 6. Cumulative eggplant fruit and shoot borer (EFSB)–infested yield of eggplants under 4 pesticide treatments (±SE)

In other studies, chilli was effective against lepidopterans (Ponce de Leon, 1983; IIRR, 1993). Hence, the study tested chilli against conventional pesticides. However, results in the study revealed that the use of hot chilli as a botanical pesticide did not control EFSB populations and simply produced marketable yield equal to the control treatment (Table 8). This is perhaps because of its active ingredient, capsaicin, which has a broad range of target organisms and kills even beneficial organisms that could be predators or competitors of EFSB (Antonious et al., 2006; NPIC, n.d.; Echezona, 2006).

Experiment II: IPM on EFSB using Ratooned Crops

Ratooning of First Crops

After 22 harvests were completed from the first crops, the plants were ratooned and 12 harvests were completed for data collection. The same IPM package as the first crops were applied but with an additional weekly dose of complete foliar fertilizer.

Yield Evaluation on Ratooned Crops

Fruits per kilogram of ratoon crops. For both first and last harvests in ratoon crops, no significant differences on the number of marketable fruits per kilogram were found. Data revealed a trend of about 11 fruits per kilogram on third harvest up to about 13 fruits per kilogram for the last (12th) harvest.

Hectare yield of ratooned crops. While the first crops produced about 40 $t{\cdot}ha^{-1}$ after 22 harvests, ratoon crops only produced about 2 $t{\cdot}ha^{-1}$ after 12 harvests. No significant differences between the gross yield of BK and DLP were found in ratoon crops, with about 2.06 $t{\cdot}ha^{-1}$ for BK and 2.17 $t{\cdot}ha^{-1}$ for DLP. Marketable yield obtained from ratoon crops under all the treatments were less than in the first crops, which had at least 43% of the gross yield as marketable. Furthermore, no significant differences between the varieties and among the pesticide treatments against EFSB were found.

Among the treatments, highest gross yield by the last harvest seemed to be from the combination treatment while the lowest gross yield was from control and synthetic treatments (Figure 7). The EFSB-infested yield was within a close range among the four treatments and relatively proportional to the gross yield, which mirror the results in the first cropping (Figure 8).

Low yield of ratooned eggplants in this study contradicts the high or comparable yields obtained from other ratooned crops such as rice (Andrade et al., 1988; Chauhan et al., 1985), sugarcane (Suman et al., 2009), and bellpepper (Kahn, 2001). It also contradicts the study of Dhankar et al. (1980), which found that ratooning is efficient in obtaining yield at a short period. However,

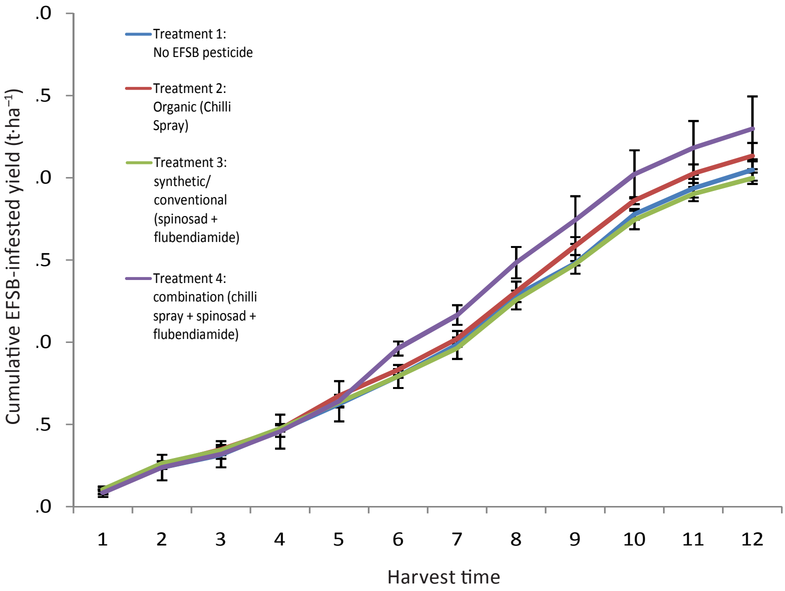

Figure 7. Cumulative gross yield of eggplants under 4 pesticide treatments against the eggplant fruit and shoot borer (EFSB) (±SD)

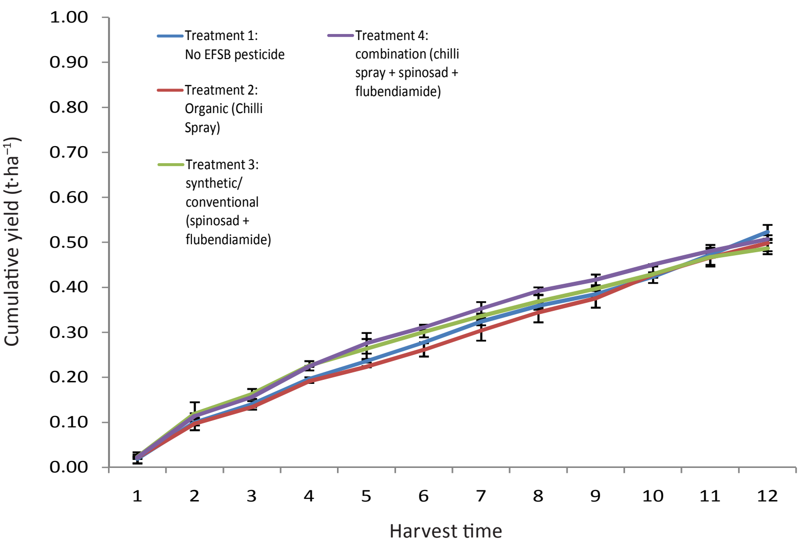

Figure 8. Cumulative eggplant fruit and shoot borer (EFSB)–infested yield of eggplants under 4 pesticide treatments (±SD)

similar results were obtained in sorghum, which had smaller panicles and few kernels in the ratoon crop compared with the first crop (Gerik et al., 1990). In a study on pigeonpeas, the researchers found that the success of ratooned crops depends on soil moisture supply, ability to ratoon of the cultivar used, and the maturity period of the crop. When crops were ratooned towards maturity, there was a decline in yield (Sharma et al., 1978).

Conclusion

Among the methods included in the IPM system of this study were crop diversification, prevention methods (i.e., mulch sheets and plant repellents), manual field sanitation, and eradication of infected parts. Also, with regulated use, pesticide was incorporated to control the EFSB population. Through crop diversification, a variety of arthropod families—namely, Aranea, Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, and Orthoptera—were observed to inhabit the site. Studies on the ecological roles of these arthropods are still ongoing.

Results reveal that regardless of variety (i.e., hybrid Banate King F1 or the open-pollinated Dumaguete Long Purple) and treatment (i.e., control, organic, synthetic, and combination), there is no difference in terms of fruit count, which remained at 10 fruits per kilogram on the 3rd harvest and about 13 fruits per kilogram on the last (22nd) harvest. Also, the yield of the eggplants reached 40 $t \cdot ha^{-1}$, which is higher than reported yields. However, even with pesticide treatment under the IPM system, EFSB damages still reached more than 10 $t \cdot ha^{-1}$ for both BK and DLP varieties. Among the four pesticide treatments, however, marketable yield was significantly higher in synthetic and combination treatments than in control and organic treatments, with no significant difference between the control and organic treatment.

In terms of yield, ratoon crops only produced about 2 $t \cdot ha^{-1}$ after 12 harvests. Ratooned eggplants also had less marketable yield under all treatments than the first crops. In addition, ratooning the crops when it has reached 22 harvests results to inferior yield compared with the first crop. Therefore, it is best to grow another batch than ratoon the eggplant crops.

The IPM system devised for the study achieved a higher gross yield than the conventional methods, even with only about 50% marketable yield in first crops and 35% in ratoon crops using the best variety and pesticide treatments. Therefore, it could be used by vegetable farmers who wish to achive higher eggplant yield using an alternative system. However, to achieve a truly succesful pesticide treatment for increased marketable yield, it is recommended that the IPM component combinations, frequency of pesticide application, and types of botanical or safer pesticides against EFSB must be explored further. Additonal studies on the degree of EFSB-infestation on agricultural fields, specifically those that are surounded by eggplants, is necessary in order to have a more precise estimate of the damage caused by EFSB. Also, variation on the time when first crops is ratooned (i.e., ratooning of younger crops compared to older crops) can be another topic for further investigation.

Acknowledgment

The authors would like to acknowledge the following institutions for providing the funding to conduct the study: United States Agency for International Development (USAID) and the Agricultural Biotechnology Support Project II (ABSP II) through the University of the Philippines Los Baños Foundation Inc. (UPLBFI) and International Service for the Acquisition of Agri-Biotech Applications (ISAAA).

Acknowledgement is also given for the contribution of the various respondents who provided relevant information: Mr. Julie Tirando and Mr. John Salming of Digos, Davao del Sur; Mr. Ruben Boclaras of Maitum, Sarangani; and Mr. Enercito Micabalo of Lantapan, Bukidnon.

References

Alam, S.N., M.A. Rashid, F.M.A. Rouf, R.C. Jhala, J.R. Patel, S. Satpathy, T.M. Shivalingaswamy, S. Rai, I. Wahundeniya, A. Cork, C. Ammaranan, and N.S. Talekar. 2003. Development of an integrated pest management strategy for eggplant fruit and shoot borer in South Asia. AVRDC - The World Vegetable Center, Tainan, Taiwan.

Andow, D.A. 1991. Vegetational diversity and arthropod population response. Annu. Rev. Entomol. 36: 561–586.

Andrade, W.E.B.D., S.A. Neto, and A.B.D. Oliveira. 1988. Rice ratooning. 08 December 2011. http://dspace.irri.org:8080/dspace/bitstream/123456789/789/1/9711041901.pdf.

Anil and P.C. Sharma. 2010. Bioefficacy of insecticides against *Leucinodes orbonalis* on brinjal. J. Environ. Biol. 31: 399–402.

Antonious, G.F., J.E. Meyer, and J.C. Snyder. 2006. Toxicity and repellency of hot pepper extracts to spider mite, *Tetranychus urticae* Koch. J. Environ. Sci. Health B 41: 1383–1391.

Báldi, A., and T. Kisbenedek. 1997. Orthopteran assemblages as indicators of grassland naturalness in Hungary. Agric. Ecosyst. Environ. 66: 121–129.

Borkent, C.J., and L.D. Harder. 2007. Flies (Diptera) as pollinators of two dioecious plants: Behaviour and implications for plant mating. Can. Entomol. 139: 235–246.

Bownes, A., M.P. Hill, and M.J. Byrne. 2010. Evaluating the impact of herbivory by a grasshopper, *Cornops aquaticum* (Orthoptera: Acrididae), on the competitive performance and biomass accumulation of water hyacinth, *Eichhornia crassipes* (Pontederiaceae). Biol. Control 53: 297–303.

Briones, R. 2009. Agricultural diversification and the fruits and vegetables subsector: Policy issues and development constraints in the Philippines. Philippine Institute for Development Studies, Makati, Philippines.

Bureau of Agricultural Statistics (BAS). 2010. Major crop statistics of the Philippines 2005–2009. Department of Agriculture, Manila, Philippines.

Bureau of Plant Industry (BPI). 2008. Plant variety gazette. BPI, Department of Agriculture, Manila, Philippines.

Bureau of Plant Industry(BPI). n.d. Recommended guidelines for national cooperative trials of vegetables. BBPI, Department of Agriculture, Manila, Philippines.

Cabrera-Asencio, I. 1998. Population dynamics of *Thrips palmi* (K.) on eggplant and pepper. J. Agri. U. Puerto Rico 82: 217–220.

Cabrera, A., A.E. Eiras, G. Gries, R. Gries, N. Urdaneta, B. Mirás, C. Badji, and K. Jaffe. 2001. Sex pheromone of tomato fruit borer, *Neoleucinodes elegantalis*. J. Chem. Ecol. 27: 2097–2107.

Chauhan, J.S., B.S. Vergara, and S.S. Lopez. 1985. Rice ratooning, pp. 1–20. International Rice Research Institute Research Paper Series no. 102.

Chupungco, A.R., D.D. Elazegui, and M.R. Nguyen. 2011. Seed system, production and marketing of eggplant in three major producing provinces in the Philippines. Philipp. J. Crop Sci. 36: 9–19.

Collins, M., and P. Bosland. 1994. Rare and novel capsaicinoid profiles in capsicum. Capsicum and Eggplant Newsletter 13: 48–51.

Dhankar, B.S., N. Mehrotra, and B. Chaudhary. 1980. Genetic divergence in normal and ratoon crops of eggplant. Indian J. Agri. Sci. 50: 144–147.

Doganlar, S.A. Frary, M.C. Daunay, R.N. Lester, and S.D. Tanksley. 2002a. A comparative genetic linkage map of eggplant (*Solanum melongena*) and its implications for genome evolution in the Solanaceae. Genetics 161: 1697–1711.

Doganlar, S.A. Frary, M.C. Daunay, R.N. Lester, and S.D. Tanksley. 2002b. Conservation of gene function in the Solanaceae as revealed by comparative mapping of domestication traits in eggplant. Genetics 161: 1713–1726.

Echezona, B. 2006. Selection of pepper cultivars (*Capsicum* spp.) for the control of bruchids *Callosobruchus maculatus* (F.) on stored cowpea (*Vigna unguiculata* [L.] Walp.) seeds. African J. Biotech. 5: 624–628.

Food and Agriculture Organisation of the United Nations (FAO). 1993–2007. Ecocrop. 05 January 2011. http://ecocrop.fao.org/ecocrop/srv/en/home.

Food and Agriculture Organisation of the United Nations (FAO). 2003. Eggplant integrated pest management: An ecological guide. FAO Inter-Country Programme for IPM in vegetables in South and Southeast Asia. FAO-RAP, Bangkok, Thailand.

Francisco, S.R. 2009. Poverty impact of Bt eggplant adoption in the Philippines. Philipp. J. Crop Sci. 34: 41–42.

Gerik, T.J., W.D. Rosenthal, and W.F. Seavey. 1990. Phenology, early growth, and yield of planted and ratoon grain sorghum. Field Crops Res. 23: 205–219.

Gotwald, W.H. 1986. The beneficial economic role of ants. In: S.B. Vinson (ed.). Economic impact and control of social insects. Praeger, New York, NY.

Hoffmann, J.H., V.C. Moran, and D.A. Zeller. 1998. Evaluation of *Cactoblastis cactorum* (Lepidoptera: Phycitidae) as a biological control agent of *Opuntia stricta* (Cactaceae) in the Kruger National Park, South Africa. Biol. Control 12: 20–24.

Hooks, C., and M. Johnson. 2003. Impact of agricultural diversification on the insect community of cruciferous crops. Crop Protect. 22: 223–238.

International Institute of Rural Reconstruction (IIRR). 1993. Bio-intensive approach to small-scale household food production. IIRR, Silang, Cavite, Philippines.

International Rice Research Institute (IRRI). 2009. CropStat 7.2. Crop Research Informatics Laboratory, International Rice Research Institute. 10 January 2011. http://archive.irri.org/science/software/cropstat.asp.

Isman, M.B. 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol. 51: 45–66.

Jagginavar, S.B., Sunitha, N.D., A.P. Biradar. 2009. Bioefficacy of flubendiamide 480 SC against brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen. Karnataka J. Agric. Sci. 22: 712–713.

Kahn, B.A. 2001. A ratoon cropping system for fall bell pepper production. HortScience 36: 897–899.

Kashyap, V., S. Vinod Kumar, C. Collonnier, F. Fusari, R. Haicour, G.L. Rotino, D. Sihachakr, and M.V. Rajam. 2003. Biotechnology of eggplant. Sci. Hortic.-Amsterdam 97: 1–25.

Kumar, H. 1997. Resistance in maize to *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae): An overview. Crop Protect. 16: 243–250.

Lahm, G., D. Cordova, and J.D. Barry. 2009. New and selective ryanodine receptor activators for insect control. Bioorg. Med. Chem. 17: 4127–4133.

Latif, M., M. Rahman, and M. Alam. 2010. Efficacy of nine insecticides against shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) in eggplant. J. Pest Sci. 83: 391–397.

Latif, M.A., M. Rahman, M.Z. Alam, and M.M. Hossain. 2009. Evaluation of flubendiamide as an IPM component for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. Munis Entomol. Zool. 4: 257–267.

Librero, A., and A. Rola. 2000. Philippines. In: M. Ali (ed.). Dynamics of vegetable production, distribution, and consumption in Asia. AVRDC - The World Vegetable Center, Tainan, Taiwan.

MacVean, C.M., and J.L. Capinera. 1992. Field evaluation of two microsporidian pathogens, an entomopathogenic nematode, and carbaryl for suppression of the Mormon cricket, *Anabrus simplex* Hald. (Orthoptera: Tettigoniidae). Biol. Control 2: 59–65.

Marino, P.C., D.A. Landis, and B.A. Hawkins. 2006. Conserving parasitoid assemblages of North American pest Lepidoptera: Does biological control by native parasitoids depend on landscape complexity? Biol. Control 37: 173–185.

Mertz, F., and R. Yao. 1990. *Saccharopolyspora spinosa* sp. nov. isolated from soil collected in sugar rum still. Int. J. Syst. Bacteriol. 40: 34–39.

Moir, M.L., and K.E.C. Brennan. 2007. Using bugs (Hemiptera) as ecological and environmental indicators in forest ecosystems, pp. 79–116. In: S.I. Muñoz (ed.). Ecology research progress. Nova Science Publishers, New York, NY.

Momen, F.M., and S.A.A. Amer. 2003. Influence of the sweet basil, *Ocimum basilicum* L., on some predacious mites of the family Phytoseiidae (Acari: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 38: 137–143.

Musolin, D.L. 2007. Insects in a warmer world: Ecological, physiological and life-history responses of true bugs (Heteroptera) to climate change. Global change Biol. 13: 1565–1585.

National Pesticide Information Center (NPIC). n.d. Capsaicin technical fact sheet. Oregon State University, Corvallis, OR.

Nyffeler, M., and G. Benz. 1987. Spiders in natural pest control: A review. J. Appl. Entomol. 103: 321–339.

Nyffeler, M., W.L. Sterling, and D.A. Dean. 1994. How spiders make a living. Environ. Entomol. 23: 1357–1367.

Olusanmi, M.J., and J.E. Amadi. 2010. Studies on the antimicrobial properties and phytochemical screening of garlic (*Allium sativum*) extracts. Ethnobot. Leaflets 14: 537–545.

Orden, M., M. Patricio, and V. Canoy. 1994. Extent of pesticide use in vegetable production in Nueva Ecija: Empirical evidence and policy implications. Research and Development Highlights 1994. Central Luzon State University, Muñoz, Philippines.

Owolabi, M.S., M.O. Oladimeji, L. Lajide, G. Singh, P. Marimuthu, and V.A. Isidorov. 2009. Bioactivity of three plant derived essential oils against the maize weevils *Sitophilus zeamais* (Motschulsky) and cowpea weevils *Callosobruchus maculatus* (Fabricius). Electron. J. Environ. Agri. Food Chem. 8: 828–835.

Panergayo, K.S., R.C. Magos, C.H. Balatero, R.A. Panergayo, E.A. Arro, E.G. Hojilla, J.V. Villamor, and D.C. Suacillo. 2008. 'Morena' and 'Banate King': New promising eggplant hybrids in the Philippines. Philipp. J. Crop Sci. 109.

Patra, S., M.L. Chatterjee, S. Mondal, and A. Samanta. 2009. Field evaluation of some new insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.). Pestic. Res. J. 21: 58–60.

Petersen, H., and M. Luxton. 1982. A comparative analysis of soil fauna populations and their role in decomposition. Oikos 39: 288–388.

Plucknett, D.L., J.P. Evenson, and W.G. Sanford. 1970. Ratoon cropping. In: N.C. Brady (ed.). Advances in agronomy. Academic Press, New York, NY.

Ponce de Leon, E.L. 1983. Further investigation of the insecticidal activity of black pepper (*Piper nigrum* L.) and red pepper (*Capsicum anuum*) on major storage pests of corn and legumes. University of the Philippines Los Banos, Collage, Laguna, MSc Thesis.

Quiroga, D., P. Arretz, and J.E. Araya. 1991. Sucking insects damaging jojoba, *Simmondsia chinensis* (Link) Schneider, and their natural enemies, in the North Central and Central regions of Chile. Crop Protect. 10: 469–472.

Racke, K. 2007. A reduced risk insecticide for organic agriculture, pp. 92–108. In: A. Felsol and K. Racke (eds.). Certified organic and biologically-derived pesticides. Environmental, Health, and Efficacy Assessment: American Chemical Society, Washington, DC.

Rainio, J., and J. Niemela. 2003. Ground beetles (Coleoptera: Carabidae) as bioindicators. Biodivers. Conserv. 12: 487–506.

Refaat, M., F.M. Momen, and S.A.A. Amer. 2002. Acaricidal activity of sweet basil and French lavender essential oils against two species of mites of the family Tetranychidae (Acari: Tetranychidae). Acta Phytopathol. Entomol. Hung. 37: 287–298.

Riechert, S.E., and L. Bishop. 1990. Prey control by an assemblage of generalist predators: Spiders in garden test systems. Ecology 71: 1441–1450.

Riechert, S.E., and K. Lawrence. 1997. Test for predation effects of single versus multiple species of generalist predators: Spiders and their insect prey. Entomol. Exp. Appl. 84: 147–155.

Sharma, D., K.B. Saxena, and J.M. Green. 1978. Potential of ratooning in pigeonpea. Field Crops Res. 1: 165–172.

Srinivasan, R. 2009. Insect and mite pests on eggplant: A field guide for indentification and management. AVRDC - The World Vegetable Center, Tainan, Taiwan. 10 January 2011. http://www.indg.in/agriculture/crop_production_techniques/Insects%20and%20mite%20pests%20on%20brinjal%202013%20A%20field%20guide.pdf.

Ssymank, A., C.A. Kearns, T. Pape, and F.C. Thompson. 2008. Pollinating flies (Diptera): A major contribution to plant diversity and agricultural production. Biodiversity 9: 86–89.

Suman, A., K.P. Singh, P. Singh, and R.L. Yadav. 2009. Carbon input, loss and storage in sub-tropical Indian inceptisol under multi-ratooning sugarcane. Soil Till. Res. 104: 221–226.

SUSVEG-Asia. 2007. SUSVEG-Asia brinjal integrated pest management (IPM). 18 January 2011. http://susveg-asia.nri.org/susvegasiabrinjalipm4.html.

Swarup, V. 1995. Genetic resources and breeding of aubergine (*Solanum melongena* L.). Acta Hort. 412: 71–79.

Vijayraghavan, K. 2010. Fruit and shoot borer resistant (FSBR) eggplant. 28 July 2011. http://www.absp2.cornell.edu/projects/intersect.cfm?productid=2&countryid=3.

Way, M.J., and K.C. Khoo. 1992. Role of ants in pest management. Annu. Rev. Entomol. 37: 479–503.

Young, O., and G. Edwards. 1990. Spiders in United States field crops and their potential effect on crops. J. Arachnol. 18: 1–27.