Impact of Intercropping Lemon Grass (*Cymbopogon citratus* Stapf.) on Infestation of Eggplant Fruit and Shoot Borer (*Leucinodes orbonalis* Guenee) in Eggplant (*Solanum melongena* L.)

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The impact of vegetation diversity through intercropping was assessed for its ability to reduce the infestation of eggplant fruit and shoot borer (EFSB), (*Leucinodes orbonalis* Guenee) on eggplant (*Solanum melongena* L.) inasmuch as insecticide use in eggplant production is quite heavy. The eggplant-chives-lemon grass cropping system did not give rise to EFSB damage. The population dynamics of insect pests and natural enemies in this mixed eggplant-herbs organic garden showed flea beetles, leafhoppers and mealy bugs while beneficial insects included ants, spiders and coccinellid beetles. In a follow-up study for two consecutive years, the effect of intercropping eggplant with lemon grass on pests populations and yield was compared with farmers' practice of insecticide use in small plot field trials at the Central Experiment Station, College of Agriculture, UP Los Baños. Eggplant intercropped with lemon grass had lower average leafhopper and aphids but there was no difference for whitefly populations compared to the monocrop. Percentage shoot damaged by EFSB in eggplant intercropped with lemon grass was significantly lower than the monocrop at 9 and 10 weeks after transplanting, although chemical control had the lowest damage. The average weight of eggplant fruit was highest for eggplant intercropped with lemon grass. Total yield in terms of number and weight of marketable fruits was significantly higher in the intercropped plots than in eggplant monoculture and farmers' practice. To elucidate the operative mechanism in the field, damage potentials and host finding behavior of EFSB in the presence of eggplant and lemon grass were investigated in the laboratory using choice and no-choice cage bioassays. A significant decrease was observed in the number of moths alighting on eggplant with lemon grass, compared to eggplant alone at 24 h after introduction. The average percent shoot damage per plant for the 1:1 eggplant-lemon grass combinations was significantly lower than eggplant alone. Our field and laboratory trials demonstrate repellency effects of intercropping lemon grass with eggplant which has the potential to reduce insecticide use in eggplant production as well as increase income of farmers.

KEYWORDS: Habitat management, intercropping, polyculture, vegetation diversity

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the most important vegetables in the Philippines in terms of volume and value of production (BAS, 2011). The eggplant fruit is a good source of potassium and it is a major part of the average Filipino diet because it can easily be prepared into various dishes. The local average production of 8.67 metric tons per hectare is low compared to the world average yield of 17.90 metric tons per hectare. Problems associated with eggplant production that contribute to low yield include arthropod pests (eggplant fruit and shoot borer [EFSB], leafhoppers, whiteflies, cutworm and mites), diseases (bacterial wilt, *Phomopsis* and *Phytophthora* fruit rot), and weeds. Farmers rely heavily on the use of chemical pesticides to control insect pests resulting in an average spray application of 40 times per cropping season that accounts for about 24% of the total cost of production (Navasero et al., 2004). There is widespread pesticide misuse ranging from wrong choice of pesticides, timing, rate and manner of application, to using restricted or banned pesticides. The situation persists in spite of several studies that showed the possibility of using non-pesticide control alternatives. Non-pesticide management tactics for EFSB include sanitation or removal and destruction of damaged plant parts and use of barrier structures like net (Arida et al., 2004), use of biological control agents like *Trichogramma* (Bustamante et al., 1994;

Gonzales et al., 2004) and earwigs (Javier, personal communication).

Four major insect pests occur regularly at high population levels during the dry season, namely *Amrasca biguttula* (Ishida), *Bemisia tabaci* (Gennadeus), EFSB, and *Thrips palmi* Karny. EFSB is the most difficult to control with insecticides. The rest had more or less occasional or sporadic occurrences. Some species were found abundant such as *Aphis gossipii* Glover, flea beetles, *Spodoptera litura* (Fabr.), *Chrysodeixis eriosoma* (Doubleday), and *Liriomyza* spp. or other species like phytophagous mites were favored by dry conditions. Only EFSB was found abundant in Batangas while this species and *Epilachna* sp. were abundant in Pangasinan during the wet season. The application of pesticides can reach as much as 40 times per season when chemical control is relied upon heavily (Navasero et al, 2004).

The effects of plant community diversity on the population dynamics of some major insect pests of eggplant were studied in mixed and monocultures of eggplant intercropped with bush sitao (*Vigna unguiculata* x *Vigna unguiculata* var. sesquipidalis), mungbean (*Vigna radiata* L.) and radish (*Raphanus sativus* L.). Significant differences were observed in the ten-week total count for EFSB.

The lowest count, of EFSB population in the three intercrops, was registered in eggplant-radish intercrop at 9 to 11 weeks after transplanting. Laboratory experiments on insect behavior, revealed a significant reduction in the average number of moths alighting on eggplant-radish combination (0.50) compared to eggplant alone (1.96) and significantly lower percent shoot damage as well (Navasero & Calumpang, 2013).

Volatile compounds are continuously emitted by plants into the air and these may be utilized by herbivores to locate their food plants. Companion planting and diversified planting utilize volatile plant chemicals which affect insect behavior. Companion planting is a cultural practice that uses plants that contain insect-repellent chemicals interspersed with other plants thus providing protection to the other plants. Most plants considered as companion plants are herbs or plants that have volatile odors. Diversified planting takes advantage of the feeding preferences of insects that locate food sources by shapes of the plants, colors and odors. Thus, mixing the plants helps decrease the attraction to insects and damage to the crops (MSU Cares). Plant chemistry is a very important source of information for insects which determines its oviposition behavior and its choice of a host plant. Acceptance or rejection of a plant is determined by the overall effect of the opposing positive and negative semiochemical cues that the insect receives from the environment (Renwick & Chew, 1994). The identification of plants (crops or weeds/ non-crops) that provide semiochemicals that serve as repellents for the insect pests and/or attractants to parasitoids is important for pest management in the field. These plants could be grown as intercrops or companion plants, thus reducing the need for chemical control.

The understanding of the chemically-mediated behavior of insects would lead to the development of an IPM component in vegetable production. The usefulness of incorporating behavioral control measures into integrated pest management systems, will surely benefit farmers through reduced dependence on commercial inputs. The insights generated by this study will be able to elucidate mechanisms that play a part in the population reduction of these economically important pests.

In the current study, we examined the influence of mixed cropping of eggplant with a variety of herbs and vegetables on the arthropod community in a diverse agricultural system. Furthermore, we determined if eggplant intercropped with lemon grass (*Cymbopogon citratus* Stapf.) could suppress major insect pest damage and increase yield of eggplant hence assess its potential as an IPM component technology for major insect pests of eggplant. As lemon grass is a common culinary herb that has similar agronomic requirements as eggplant, a source of essential oil of commercial value (Elson et al., 1989; Lee et al., 2008; Ojo et al., 2006), and a popularly known repellent against mosquitoes (Oyedele et al., 2002), we studied the effects of lemon grass on the host finding and oviposition behavior of EFSB in laboratory cage experiments.

MATERIALS AND METHODS

Eggplant-Chives-Lemon Grass-Flowering Plants Field Trials

A preliminary trial on mixed herb-vegetables was conducted in the Institute of Plant Breeding, University of the Philippines Los Baños experimental area in the wet season of 2003. The area was maintained for organic vegetable production and previously planted with various vegetables intercropped with various herbs such as onion, garlic, and bordered by lemon grass (*Cymbopogon citratus* (DC.) Stapf, sunflower (*Helianthus annuus* L.), cosmos (*Cosmos bipinnatus* Cav.), oregano (*Coleus aromaticus* Benth.), and marigold (*Tagetes erecta* L.).

Figure 1. Field trial of eggplant intercropped with lemon grass.

Eggplant was intercropped with chives (*Allium schoenoprasum* L.) in 1000 m^2 of land and sunflower, cosmos, marigold and lemon grass were planted in the borders. No pesticides and synthetic fertilizer were applied. Ten bags of chicken manure were broadcast in the area before planting and an organic liquid fertilizer was sprayed on the furrows as additional basal fertilizer.

Insect pests and natural enemies were monitored using visual count and sweep-net methods done on the same day with visual counts done before sweeping. Visual counts were done for 10 plants in half of the plot so as not to disturb the whole plot. Ten sweeps were likewise made in the other half of the plot. Samples from sweeping were sorted, identified and added to visual counts as total insect counts. Aphids were assessed according to the standard aphids rating scale: 1 = no aphids, 3 = presence of winged adult, 5 = presence of 1 colony, 7 = presence of 2 or more distinct colonies, 9 = colonies indistinct/overlapping.

Eggplant-Lemon Grass Field Trial

With the observed arthropod pest reduction in the mixed herb vegetable garden, a follow-up experiment was later set-up in a 0.5 ha field at the University of the Philippines Los Baños Central Experiment Station (Figure 1). The field was plowed and harrowed twice and furrowed at 0.50 m apart. Eggplant seedlings (cv. Casino), were planted on the ridge at a distance of 0.75 m between hills on June 2008 and a second trial was planted on June 2013. Lemon grass plants were planted earlier, with a planting distance of 1.5m. between

Table 1.

Insecticides Applied in Farmers' Practice Plots (NCPC, 2008).

WAT	Brand (Active ingredient)	Rate	WAT
1	Actara –drench (Thiametoxam)	2g/16L	1
7	Agrimek (Abamectin)	20ml/100L	3
8	Cartap	1.5 tbs/16L	4
9	Fenos(Flubendiamide)	75 ml/ha	5
11	Fenos(Flubendiamide)	75 ml/ha	6
13	Fenos(Flubendiamide)	75 ml/ha	7

hills and 0.75 m between rows. Eggplant intercropped with lemon grass, eggplant monocrop and farmers' practice plots were laid out in a randomized complete block design (RCBD) with 4 replications. Treated and control plots (10 x 10m) had a 2 m buffer zone between treatments and 1.5 m between replicates. Irrigation and fertilization were done regularly. Farmers' practice involved weekly spraying of insecticides (Table 1)

Weekly counts of pests and beneficial insects started 2 weeks after transplanting. Data gathered include weekly monitoring of insect populations, damage of pests to the crop and crop yield. Insect populations were based on weekly actual counts/20 sample plants/ plot. Harvesting in 20 sample plants was done twice a week up to 12 primings while damage assessment for EFSB was done weekly. Damaged and marketable fruits, damaged and undamaged shoots and yield data were likewise collected. The data were averaged per hill and analyzed using the F-test ANOVA. Difference between individual treatments were tested for significance using Least Significant Difference (LSD) test.

Insect Collection and Rearing

EFSB larvae were collected from infested eggplant fruits in Calamba, Laguna, Philippines. These were reared in the laboratory in plastic pans lined with paper towel and fed daily with chips of eggplant fruits under controlled temperature (28^{o}C), 16 h light:8 h darkness and relative humidity of (70-80%). Pupae were subsequently collected and placed in Petri plates for holding. When about to emerge, pupae were placed in a cage and emerged adults were transferred to egg-laying chambers for mating and oviposition. The egg-laying chamber was a glass ball jar with mesh cloth strips for oviposition. A cotton ball soaked in 10% sucrose, hung on a wire attached to the mesh cloth cover, was offered as adult food. After 3-4 days, adults were removed and the mesh cloth strips with egg masses were transferred to eggplant chips for further rearing according to the method described by Gonzales (1999).

Damage potential laboratory bioassays

The response of EFSB adults was observed in screen cages using potted eggplant (flowering stage) and lemon grass in choice and no-choice tests in laboratory from January 2008 to March 2009. One potted eggplant and one lemon grass plant were placed inside wire screen cages (75 cm x 75 cm x 150 cm) after that, 2 males and 2 females of the laboratory reared mated adult moths were released into the cage. Shoot damage was monitored and assessed 2 weeks after introduction. The number of damaged shoots was counted and percent damaged computed based on total number of shoots per plant. Each cage setup represented one replicate and the experiment was replicated 25 times. Different sets of adults were used for each replicate. The assays were conducted in ambient room conditions (32^{o}C; 70-80% RH).

Host-finding behavior laboratory bioassays

The response of EFSB adults was observed in screen cages using potted eggplant (flowering stage) and lemon grass in choice and no-choice tests in laboratory from January 2010 to November 2012. One potted eggplant and one lemon grass plant were placed inside wire screen cages (75 cm x 75 cm x 150 cm) after which, 4 virgin females of the laboratory reared moths were released into the cage. The behavior was monitored by recording if they alighted on the plant or on the cage at 0, 1, 2, 3, 4, 5, 6, 7 and 24 h after introduction under dark room conditions, with 3 hours artificial light prior to 24 h readings. Controls were exposed to 1 potted eggplant per cage in a separate room from the choice test setups. The assays were conducted in ambient room conditions (32^{o}C; 70-80% RH). The adults were used only once. Each cage setup represented one replicate and the experiment was replicated 25 times.

Table 2.

Total Insect Counts in Organically Grown Eggplant Intercropped with Chives, and Bordered with Lemon Grass at the Flowering/Fruiting Stage (1 Month After Transplanting), IPB, UPLB 2002.

	1 WAT	2 WAT	3 WAT	4 WAT	5 WAT	6 WAT	7 WAT	8 WAT
Insect pests								
Leafhoppers	2	91	279	240	271	274	246	316
Flea beetles	35	10	22	19	19	23	38	56
Whiteflies	3	0	0	18	3	2	1	3
Cutworm	9	15	0	0	1	1	1	0
Aphids	0	1.5	3	2.14	1.16	1.4	1.34	1.07
Semi-loopers	1	1	0	2	0	0	0	0
Fruit/shoot borers	0	0	0	0	0	0	0	0
Pentatomid	0	2	1	3	0	0	0	0
Natural enemies								
Spiders	2	4	16	11	3	10	15	4
Coccinelids	0	4	18	7	3	10	3	2
Ants	1	10	3	121	5	12	14	7

RESULTS AND DISCUSSION

Arthropod Populations in Eggplant Intercropped with Chives and Lemon Grass

The dominant insect observed during the entire season was green leafhoppers (*Amarasca bigutulla*) (Table 2). Leafhopper counts increased from 2 to 91 from 1 to 2 WAT, increasing to 316 at 8 WAT. On the other hand, EFSB was practically nil throughout the sampling period. Flea beetles, cutworm and whiteflies were also observed but counts were low. Flea beetles were recorded on the 2nd week until the last sweeping. A minimal number of aphids and semilooper (1-3 per plants) were always present during the monitoring period (Table 2).

This mixed herb-eggplant cropping system did not give rise to EFSB damage although leafhopper counts were not reduced. Natural enemies, such as ants (black and red), spiders and coccinelids were observed. The highest numbers were recorded for ants (121), followed by coccinelids (2-18) and spiders (2-16). These insects feed on soft-bodied insects, such as aphids, whiteflies and cutworm larvae and serve to reduce insect pest populations.

Table 3.

Mean Number of Plant Hoppers, Aphids and Whiteflies in Eggplant Intercropped with Lemon Grass Compared with Farmers' Practice from 2 to 10 Weeks after Transplanting (WAT) 2008.

Hoppers	**2 WAT**	**3 WAT**	**4 WAT**	**5 WAT**	**6 WAT**	**7 WAT**	**8 WAT**	**9 WAT**	**10 WAT**
With lemon grass	1.125 a	0.575 b	0.800 b	0.475 b	1.175 a	1.175 a	0.975 a	1.425 a	1.125 ab
Eggplant alone	1.300 a	1.450 a	1.250 a	1.100 a	1.325 a	1.450 a	1.525 a	1.875 a	2.250 a
Farmers' practice	0.260 b	0.100 c	0.300 c	0.483 b	0.383 b	0.600 a	1.050 a	0.740 b	0.900 b
Significance Level	1%	1%	1%	5%	1%	ns	ns	5%	1%
Aphids	**2 WAT**	**3 WAT**	**4 WAT**	**5 WAT**	**6 WAT**	**7 WAT**	**8 WAT**	**9 WAT**	**10 WAT**
With lemon grass	1.225 a	0.850 b	1.400 b	0.400 a	0.425 b	0 b	0 b	0 a	0 a
Eggplant alone	1.550 a	2.050 a	2.600 a	2.175 a	2.225 a	1.250 a	0.650 a	0.075 a	0.200 a
Farmers' practice	0.083 a	0.265 c	0.050 c	0.633 a	0 c	0 b	0 b	0 a	0 a
Significance Level	ns	1%	5%	ns	1%	5%	1%	ns	ns
Whiteflies	**2 WAT**	**3 WAT**	**4 WAT**	**5 WAT**	**6 WAT**	**7 WAT**	**8 WAT**	**9 WAT**	**10 WAT**
With lemon grass	0.075 a	0.025 b	0 a	0.125 b	0.100 a	0.150 a	0.150 a	0.125 a	0.100 a
Eggplant alone	0.325 a	0.025 b	0.275 a	0.125 b	0.250 a	0.125 a	0.225 a	0.500 a	0.375 a
Farmers' practice	0.150 a	0.218 a	0.183 a	0.465 a	0.440 a	0.218 a	0.290 a	0.283 a	0.150 a
Significance Level	5%	1%	ns	5%	ns	ns	ns	ns	ns

Average of 4 replicates, 10 plants per replicate

In a column, means followed by the same letter are not significantly different based on F-test ANOVA and LSD at the significance level indicated.

In general, the intercropping of lemon grass with eggplant reduced the populations of the three major insect pests, green leafhoppers, aphids and whiteflies compared to the monocrop (Table 3). The leafhopper counts were significantly lower in eggplant with lemon grass ($P<0.01$, F-test ANOVA and LSD) at 3 to 5 WAT compared with eggplant monocrop but it had higher leafhopper count than that of farmers' practice only at 2 to 4 WAT and 6 WAT.

Lemon grass intercropping produced significant reduction on aphid populations, which were lower in intercropped plots compared to monocrop plots, in general, throughout the sampling period representing peak of fruit period at 3 to 8 WAT (Table 3). Aphid populations were observed only until 5 and 6 WAT for farmers' practice and lemon grass intercrop, respectively and significantly lower counts in the former than the latter were recorded at 3, 4, and 6 WAT. Lemon grass intercrop also reduced whiteflies when compared with the monocrop and farmers' practice. Farmers' practice of drenching the seedlings with thiamethoxam at 1 WAT and spraying other insecticides (Table 1) resulted in lower leafhopper and aphid counts than eggplant monocrop and eggplant intercropped with lemon grass. The insecticides used in the 2008 trial were not able to control whiteflies adequately. However, reduced whitefly count in eggplant monocrop and eggplant intercropped with lemon grass as compared to the farmers' practice may actually be due to dominance of leafhopper over whitefly. A population dynamics study by Navasero (2004) showed that a higher population of leafhoppers results in yellowing of leaves which appear to be less preferred by whiteflies.

These results indicate that lemon grass has the potential to reduce hoppers and aphids populations in the production of eggplant. This agrees with the reduced insect counts observed in eggplant grown with selected culinary herbs (Gonzales et al., 2004).

The reduction in leafhopper populations is quite significant considering that eggplant var. Casino is very susceptible to leafhoppers (Lit et al., 2002). In addition to reducing insect pest populations, lemon grass is a good intercrop as it has commercial pharmaceutical, fragrance, and medicinal value (Elson et al., 1989; Lee et al., 2008; Ojo et al., 2006) as well as anticancer properties (Lee et al., 2008). It is also an important source of essential oils which include several bioactive marker compounds such as neral, geranial, geraniol, limonene, citronellal, and β-myrcene (Schaneberg & Khan, 2002). Chemicals that possess insecticidal activity against the larvae of diamondback moth, *Plutella xylostella* L. (Lepidoptera: Yponomeutidae), larvae were found in the essential oil of lemon grass, such as 3,7-dimethyl-2,6,-octadienal or citral. (Dadang & Ohsawa, 2009). On the other hand, volatile organic chemicals found in lemon grass, such as limonene was demonstrated to have significant repellent and oviposition deterrent effects on *P. xylostella* (Liang et al., 2004). Limonene is also found in the volatiles emitted by red clover (*Trifolium pratense* L.) root extracts and repelled the red clover borer (*Hylastinus obscurus* Marshami) in olfactometric bioassays (Tapia et al., 2007).

Eggplant Shoot Damage

Lemon grass reduced EFSB populations as evidenced by the lower number of damaged shoots in plots with eggplant intercropped with lemon grass than those in monocropped plots at 8 to 10 WAT (Table 4). Percent shoot damage in eggplant grown with lemon grass ranged from 4.82 to 5.26% and was lower than that in eggplant grown without lemon grass (7 to 12%) which were statistically significant at 9 to 10 WAT. However, the percentage of damaged shoots in farmers' practice plots was significantly lower (0.5% and 2.17%) than both treatments indicating better control of ESFB using insecticides (Table 4).

Table 4.

Mean Number of Damaged Shoots/Plant From 8 to 10 Weeks After Transplanting (WAT).

	2008, Wet season		
	8 WAT	**9 WAT**	**10 WAT**
Number of damaged shoots			
With lemon grass	4.75 b	5.00 b	4.75 b
Eggplant alone	6.25 a	8.25 a	11.00 a
Farmers' practice	0.133 c	0.017 c	0 c
Percent shoot damage			
With lemon grass	5.26 a	4.85 b	4.82 b
Eggplant alone	7.29 a	9.27 a	12.08 a
Farmers' practice	2.17 a	0.168 c	0 c

Average of 3 replicates, 10 plants per replicate
In a column, means followed by the same letter are not significantly different based on F-test ANOVA and LSD at 1 % significance.

Table 5.

Average Yield of Eggplant Intercropped With Lemon Grass.

Treatments	2008, Wet Season		
	Total Number of Marketable Fruits	**Total Weight (g)**	**Weight of Fruit (g/fruit)**
Grown with lemon grass	79.0 a	6063.75 a	78.13 a
Grown without lemon grass	60.0 b	3512.50 b	59.46 a
Farmers' practice	48.30 b	3515.00 b	72.39 a
Significance level	5%	1%	ns

In each column, means followed by the same letter are not significantly different based on F-test ANOVA and LSD test.

Eggplant Yield

Total yield of intercropped eggplant was significantly higher than the eggplant monoculture (Table 5). Subsequently, yield of marketable eggplant was significantly higher in plots grown with lemon grass. Yield from farmers' practice plots were lower due to the incidence of fruit rot on eggplant (28%) (Gonzales et al., 2007).

Similar results using other herbs were reported recently, coriander and fennel were found to be equally effective in reducing EFSB infestation when intercropped with eggplant. Total yield of intercropped eggplant was significantly higher than the eggplant monoculture yield (Satpathy & Mishra, 2011). In another study by Quisay and Roxas (2004), intercropping of eggplant with several vegetables, okra, string beans, corn and pepper resulted in more (number and weight) marketable fruits. There were significantly higher populations of leafhopper, thrips, mites, and EFSB during the entire observation period in the plots planted solely to eggplant than in those with intercrops.

Volatiles have also been demonstrated to protect plants by attracting herbivore natural enemies, such as parasitic wasps, predatory arthropods and possibly even insectivorous birds (Unsicker et al., 2009). Beneficials and herbivores are attracted by chemical cues. Benzaldehyde and phenylacetaldehyde attract both pollinators and florivores (Theis, 2006). Syrphid flies use olfactory and not visual cues to find a pollen/nectar host-plant. Among the compounds eliciting

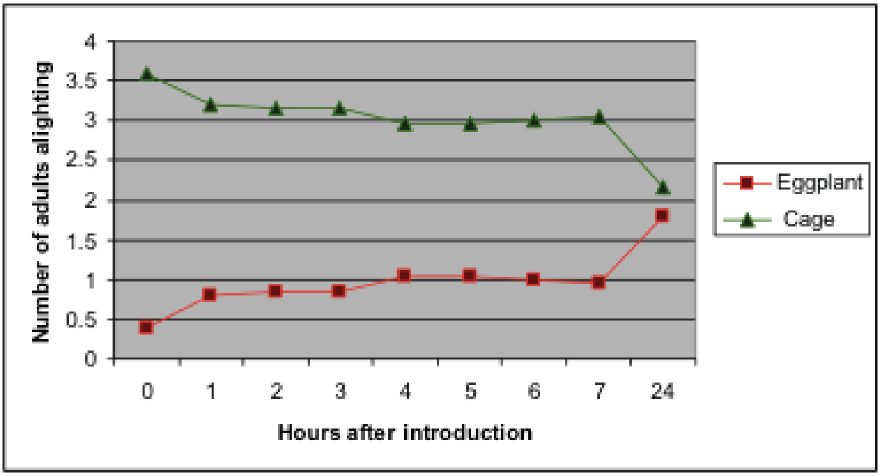

Figure 2. Number of eggplant fruit and shoot borer (*Leucinodes orbonalis* Guenee) adults alighting on eggplant in cage experiments.

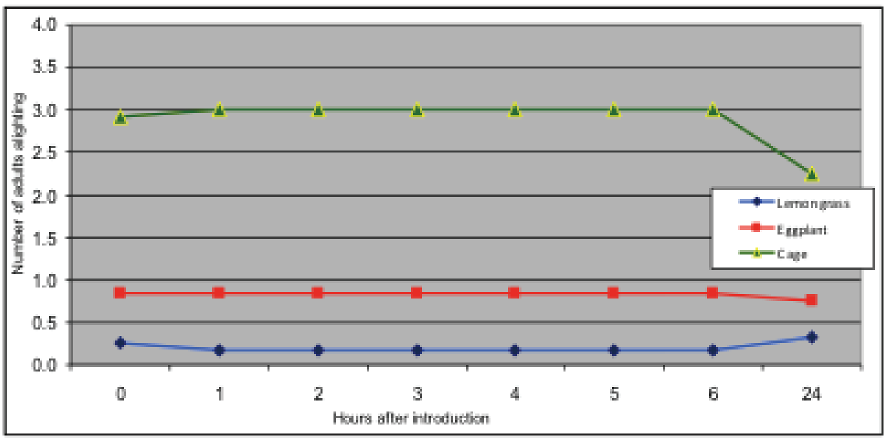

Figure 3. Number of eggplant fruit and shoot borer (*Leucinodes orbonalis* Guenee) adults alighting on eggplant (*Solanum melongena*) and lemon grass, (*Cymbopogon citratus*) (1:1) in cage experiments.

an antennal response in syrphid flies are methyl salicylate and 2-phenylethanol (Primante & Dötterl, 2010). Floral volatiles serve as attractants for species-specific pollinators (Pichersky & Gershenzon, 2002). *Mythimna separata* caterpillars utilize plant volatile information to modulate their daily activity patterns, thereby potentially avoiding the threat of parasitism (Shiojiri et al., 2006).

Intercropping of lemon grass with eggplant, essentially reduces the need for insecticides to control eggplant fruit shoot borer, leafhoppers and aphids. It can be used to complement other biological control methods to reduce use of insecticides for low input farming. Nucleopolyhedrosis virus (NPV) is now used by farmers in Central Luzon to control cutworm infestation (Navasero & Navasero, 2003). This could reduce farm inputs for eggplant where insecticide use is heavy, reaching up to 40 times per season in some areas (Navasero et al., 2004).

Host finding behavior

Basic studies on EFSB behavior in cage experiments were conducted to elucidate the mechanism for its reduced counts in eggplant-lemon grass intercrop. No-choice cage bioassays showed EFSB adults constantly alighted on the eggplant leaves and shoots immediately after introduction, with 1 adult spending about 1-2 min on the leaves within the first 7 h. The number increased to about 1.8 per plant at 24 and 48 h after introduction (Figure 2) but this was reduced to 0.8 EFSB moths on eggplant when lemon grass was present (Figure 3). Female EFSB hardly alight on the lemon grass plant, preferring to stay on the cage screen most of the time. These observations show that lemon grass repels EFSB and its presence with eggplant reduces the opportunity for EFSB ovipositing on fruits and shoots of eggplant. This phenomenon explains the decrease in eggplant shoot damage resulting in an increase in number and weight of marketable eggplant fruits when lemon grass is intercropped with eggplant in the field.

CONCLUSIONS

Intercropping fits into environmentally acceptable and sustainable vegetable production. Intercropping of eggplant with herbs can reduce populations of some insect pests in the field. A mixed garden of eggplant with several herbs demonstrated reduced eggplant EFSB damage but was not able to manage leafhopper populations. On the other hand, lemon grass when intercropped with eggplant, reduced hoppers, aphids and whiteflies, and shoot damage caused by EFSB, subsequently increasing the yield of eggplant in small plot field trials.

Laboratory insect behavior studies demonstrated reduced alighting on eggplant when lemon grass was present which is consistent with field trial results. Volatile organic chemicals of lemon grass repel EFSB female adults thus disturbing the host finding behavior of the adults in the field. This behavior explains the observed reduction in fruit and shoot damage in the field.

Intercropping of eggplant with lemon grass provides the potential for increasing income of farmers while providing options for pest management which can reduce insecticide use. This cropping system needs to be further evaluated on a larger scale as both economic and ecological conditions must be fully evaluated before an economic intercropping-based commercial production scheme can be recommended.

ACKNOWLEDGMENT

This research was funded in part by the Department of Agriculture-Bureau of Agricultural Research and the National Crop Protection Center, College of Agriculture, UP Los Baños Core Funds in 2007 to 2010. The authors wish to acknowledge the assistance of Ms. Gloria Rodolfo, Institute of Plant Breeding, UPLB who maintained the organic mixed herb vegetable garden and Ms. Emilia D. Valondo for her assistance in the insect behavior bioassays.

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