BEHAVIORAL RESPONSE OF *Spodoptera litura* (F) (Lepidoptera: Noctuidae) TO SELECTED HERBS AND EGGPLANT

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(Received: August 1, 2013; Accepted: December 3, 2013)

ABSTRACT

Oviposition preference and behavioral bioassays were conducted to determine suitable companion plants for the management of the common cutworm *Spodoptera litura* (F) (Lepidoptera: Noctuidae) in eggplant (*Solanum melongena*). The effects of selected plants on the larval development and survival of *S. litura*, were studied under laboratory conditions. Choice tests demonstrated fewer cutworm egg masses on eggplant presented together with either lemon grass, oregano or basil than sole eggplant over a 24 h period. On the other hand, marigold increased the number of egg masses on eggplant. Larval survival and development of the common cutworm indicate that eggplant, lemon grass, oregano, and *Ageratum conyzoides* leaves cannot support larval growth. Field trials need to be conducted to verify that lemon grass, oregano and basil can serve as good companion herbs for eggplant.

Key words: larval development, oviposition preference, companion plants

INTRODUCTION

Common cutworm, *Spodoptera litura* (F) is a polyphagous insect that was previously considered as a minor or an occasional pest in the Philippines. However, this is beginning to be a perennial problem in many crops. It feeds on a wide variety of plants, including tomato, rice, corn, eggplant, potato, sweet and hot peppers, tobacco (Zhou et al 2010), cotton, okra, cabbage, pechay, cauliflower, radish, gabi, peanut and other legumes (Navasero and Navasero, 2011). Because of its broad host range, this insect is also known as cluster caterpillar, common cutworm, cotton leafworm, tobacco cutworm, tobacco caterpillar, and tropical armyworm. Trichogramma and *Telenomus nawai* wasps prey on cutworm eggs (MacGregor et al 1998). Nuclear polyhedrosis virus (NPV-cutworm or SlNPV) can likewise be used to manage cutworm larvae in the field (Navasero and Navasero, 2003; Fukuda et al, 2007).

Larval feeding, particularly their direct damage on leaves and fruits, results in significant yield reduction. Thus, farmers resort to increased reliance on insecticide use. Pesticide use in eggplant production in the Philippines can be quite heavy due to the pest complex and related insecticide resistance concerns (Navasero et al, 2004). There is therefore a compelling need to come up with pest management strategies to reduce insecticide use.

Agricultural diversification has received attention and its impact on the insect community may be due to reduced colonization, reduced adult tenure time in the marketable crop, and oviposition interference. Intercropping of crop plants is common in the tropics; it has influence on pest population dynamics which ensures food security and additional income to farmers through minimizing crop damage (Perrin and Phillips, 1978). Manipulative studies provide some evidence that habitat manipulation techniques (e.g. intercropping, vegetation borders and undersown nonhost plants) impact crop growth in crucifers (Hooks and Johnson, 2003).

Eggplant can be intercropped with some vegetables to reduce pest damage. Intercropping eggplant with cowpea is shown to reduce the whitefly population density on eggplant (Binyason, 2008). Intercropping of eggplant and radish resulted in lower population of the most serious pest of eggplant, eggplant fruit and shoot borer (EFSB), compared to eggplant alone. The repellency of radish to EFSB was likewise demonstrated in the changes in its host finding behavior and reduced damage potential (Navasero and Calumpang, 2013).

There is therefore a need to explore other ecological approaches for insect pest management such as cultural control for eggplant. The key objective of our study was to determine the effect of selected plants (crops, herbs and weeds) on the oviposition preference and host-finding behavior of common cutworm as well as the mobility and the feeding activity of larvae to enhance repellency for this insect pest.

MATERIALS AND METHODS

Plants and Insects

Eggplant (*Solanum melongena*) was grown in plastic bags and fertilized with urea and complete fertilizer (14-14-14) in the experimental area at the National Crop Protection Center, University of the Philippines Los Baños. Selected herbs marigold (*Tagetes erecta* L.), lemon grass (*Cymbopogon citratus* (DC) Stapf.), basil (*Ocimum basilicum*) and oregano (*Coleus aromaticus* Benth.) were likewise tested as some are known to have biological activity and have commercial and health value that could be an important consideration.

S. litura larvae were collected from the Central Experiment Station, College of Agriculture, University of the Philippines Los Baños in Laguna, Philippines and routinely mass reared in the laboratory on castor leaves at 28-29^{o}C, L16:D8 photoperiod and relative humidity (70-80%). Pupae were subsequently collected and placed in tissue-lined Petri plates for holding. When about to emerge, the pupae were placed in a cage. After adult emergence, moths were kept in an egg-laying chamber for mating and oviposition. The egg-laying chamber was a screen cage (75 x 75 x 150 cm) where a cotton ball soaked in 10 percent sucrose solution was offered as adult food. Sweet potato cuttings were offered as oviposition sites and leaves with egg masses were collected and transferred to a plastic container containing clean fresh castor leaves for further rearing.

Oviposition preference bioassay

The oviposition response of common cutworm adults was observed in screen cage experiments using eggplant together with either lemon grass, oregano, basil and marigold. This oviposition response was compared with that of cutworm adults on eggplant alone. Bioassays were conducted using potted eggplant and test plants in choice and no-choice tests in the laboratory from from February 2008 to May 2013. One potted eggplant (4-5 wk old) and one mature potted test plant were placed inside cages (75 x 75 x 150 cm) where two males and two females of laboratory reared adults were released. The number of egg masses was counted on eggplant and the test plant at 48 hours after introduction under dark room conditions. Controls were exposed to 1 potted eggplant per cage in a separate room from the choice test setups. All the tests were conducted at ambient room conditions (28 to 32^{o}C). The adults were used only once. Each cage setup represented one replicate and the experiment was replicated 15 times.

Host-plant finding behavior

Bioassays were conducted using potted eggplant in choice and no choice tests in the laboratory to evaluate the behavior of female common cutworm. One potted eggplant (5-6 weeks old) and one potted test plant were placed inside cages (75 x 75 x 150 cm) where four females of laboratory reared adults were released. The behavior of the adults was monitored by recording the matrix where they alighted on at 0, 1, 2, 3, 6 and 24 hours after introduction under dark room conditions. These were repetitive measures of the same cage at each time point. Controls were exposed to 1 potted eggplant per cage in a separate room from the choice test setups. All of the tests were conducted at ambient room conditions (28-32^{o}C). The adults were used only once. Each cage setup represented one replicate and the experiment was replicated 25 times.

Larval mobility

The mobility of cutworm larvae on eggplant and selected test plants was assessed using 3rd instar larvae. Five larvae were introduced on each potted test plant with 25 replicates per treatment. The plants were placed 1.5 m apart under ambient room conditions (temperature: 28 to 32^{o}C; ambient sunlight). The number of larvae remaining on the test plant was monitored 1, 2, 3, 6 and 24 h after introduction. Potted eggplant was used as control. Each potted plant represented one replicate and the experiment was replicated 25 times.

Larval feeding and survival

The larval feeding set-up consisted of 25 3rd instar cutworm larvae individually placed in rectangle plastic containers and fed with leaves and stems of selected test plants which were replaced every day. The larvae were observed daily until pupation or death, numbers of which were recorded. Pechay leaves were used as control. The experiments were conducted in an air-conditioned room at 28^{o}C. Each container represented one replicate and the experiment was replicated 25 times. The experiment was conducted as blocks of 5 replicates per day for 5 d.

Statistical analysis

The data obtained in the larval feeding were statistically analyzed by using SAS version 9.0 Poisson generalized linear model (GLM). Tukey's Studentized Range (HSD) multiple comparison tests were used to test for significant differences between individual treatments. The data obtained in the host-finding and oviposition preference bioassays were statistically analyzed by using the t-Test independent samples. Larval behavior statistical analysis was done using Tukey's Studentized Range (HSD) test (SAS version 9.0).

RESULTS AND DISCUSSION

Oviposition preference

Considerable reduction in the number of egg masses on eggplant was observed when lemon grass, oregano or basil were presented as companion plants (Table 1). The number of egg masses on the companion plant represented 82 to 94% of the total number of egg masses. In the presence of either lemon grass and oregano, the number of egg masses on eggplant decreased from 5.7 to 0.2 and 0.1, respectively. The number of eggmasses on eggplant and on these herbs were significantly different. The results suggest that the lemon grass and oregano affect tenure of the cutworm female on eggplant resulting in less egg masses. Thus, lemon grass and oregano would be good intercrops or companion herbs with eggplant in mixed vegetable gardens for organic vegetable production. When marigold was presented together with eggplant, the number of egg masses on marigold was high, almost twice as much as those on the other herbs. These results suggest that marigold has the potential as a trap crop, where it can be planted as a border or in islands in the field, to lure the cutworm away from eggplant, and SlNPV or Bt insecticide can be applied as spot treatment, both of which are compatible with Trichogramma as a biological control agent.

Table 1. Distribution of egg masses of the common cutworm on eggplant with companion plants in oviposition preference bioassays.

Treatment	Number of egg masses		Percent of companion plant with egg masses
	On eggplant	**On companion plant**	
Eggplant + Lemon grass	0.2 ± 0.6 a	2.0 ± 1.3 b	80
Eggplant + Oregano	0.1 ± 0.3 a	2.1 ± 1.3 b	80
Eggplant + Marigold	1.4 ± 1.4 a	5.5 ± 3.2 b	93
Eggplant + Basil	0.9 ± 1.4 a	2.3 ± 2.4 a	60
Eggplant alone	5.7 ± 4.1	-	-

*Based on means of 15 replications (4 female adults per replication). Means in a row followed by a common letter are not significantly different at 1% probability level using t-Test for independent samples (SAS version 9.0).

Related experiments using pure chemicals demonstrated oviposition deterrence effects on cutworm using the chemicals geijerene and pregeijerene on tobacco cutworm, *Spodoptera litura* (F.) (Kiran et al, 2006). Field trials also demonstrated taro (*Colocasia esculenta* (L.) as an effective trap crop for managing *S. litura* on tobacco (Zhou et al, 2010).

Basil can be a good companion crop as it is an aromatic plant and insects use chemical cues for host-finding. Intercropping field trials using repellent plants such as basil, mint and citronella showed the lowest number of diamondback moth larvae on Chinese kale was recorded from basil plots, followed by mint and citronella and the highest yield was harvested from the mint plots, which was also higher than from chemical treatment (Shrestha, 1992). Non-host plant volatiles have been implicated in influencing the imported cabbageworm, *Artogeia rapae* L. egg distribution in collard plants interplanted with a herb mixture (Latheef and Ortiz, 1983) or tomato (Maguire, 1984). Unfamiliar volatile chemicals could alter the landing behavior of insects as reflected an avoidance reaction to nonhost plants (Renwick and Radke, 1988).

Host-plant finding behavior

Although eggplant has been documented as an alternate host of cutworm (Navasero and Navasero, 2011) the adult host-plant finding behavior in cage conditions does not show a strong attractancy for cutworm if there are no eggplant fruits (Fig. 1) as cutworm larvae feed on the eggplant fruits.

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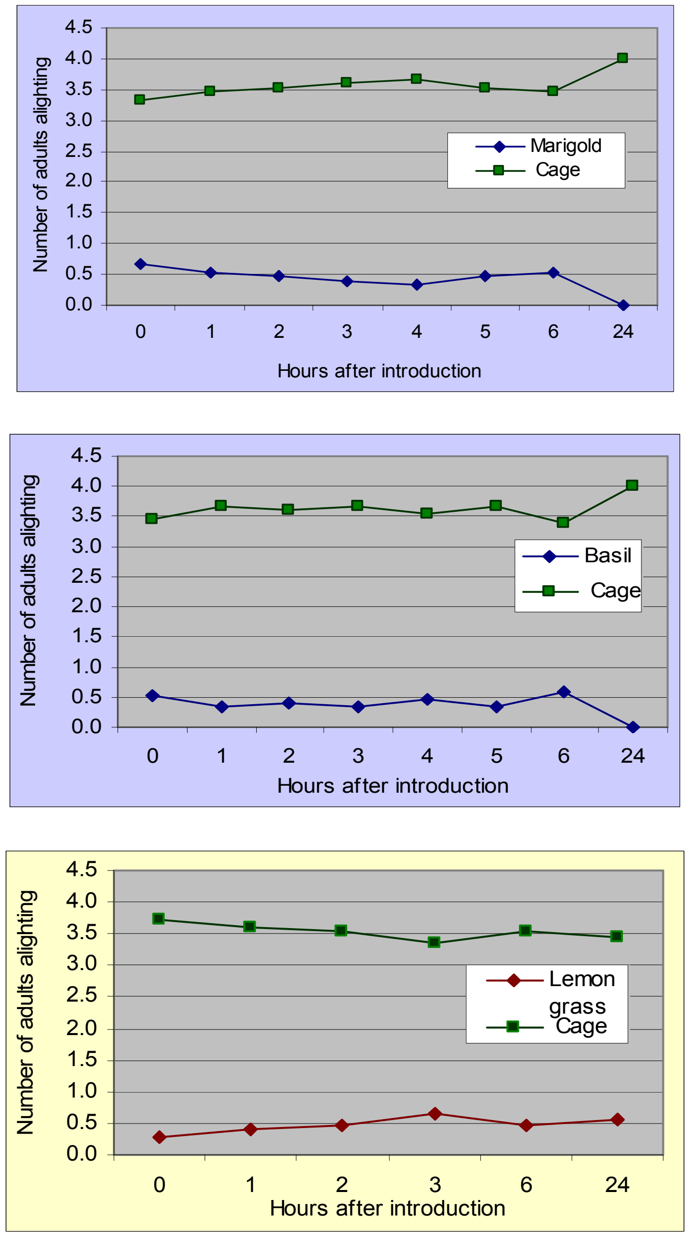
Fig. 1. Number of cutworm adults alighting on eggplant in host-finding bioassays (4 female adults per cage).

Adult behavior on the herbs generally showed that common cutworm adults did not prefer to alight on the herbs (Fig. 2). Although eggs were oviposited on marigold and basil, the moths were observed to stay away from these plants 24 h after introduction. Thus, the number of eggs laid on eggplant was significantly lower than eggplant alone. Appropriate and inappropriate landings could be responsible for fewer herbivores found on host plant in the company of nonhost plants (Finch 1996) as well as odors emitted by certain nonhost plants can disrupt the attraction of the insects to host plants by repellency and odor masking.



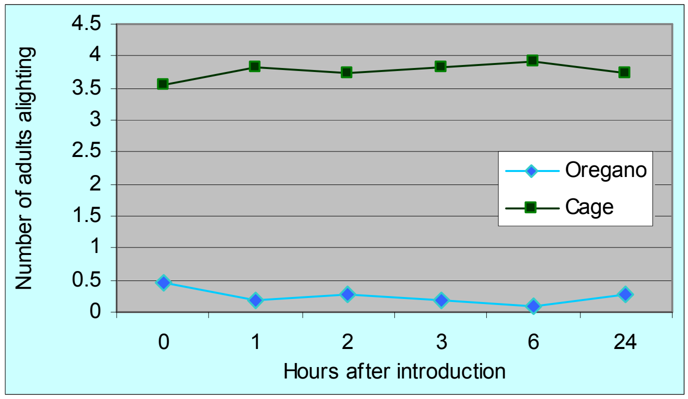


Fig. 2. Number of cutworm adults alighting on marigold, basil, lemon grass and oregano in host-finding bioassays (4 female adults per cage).

Even in the presence of eggplant, cutworm also did not spend much time alighting on *Ageratum conyzoides*, a weed closely associated with vegetables (Fig. 3). Ageratum can be selectively maintained along borders to manage cutworm infestation. Reduced colonization of insects within a field can be the first line of defense in preventing pest outbreaks. Intercropping or border strips offer potentials for reduced herbivore population. Additional plant flora within crop rows increases the ratio of plant to soil background, thus camouflaging the host plant (Hooks and Johnson 2003).

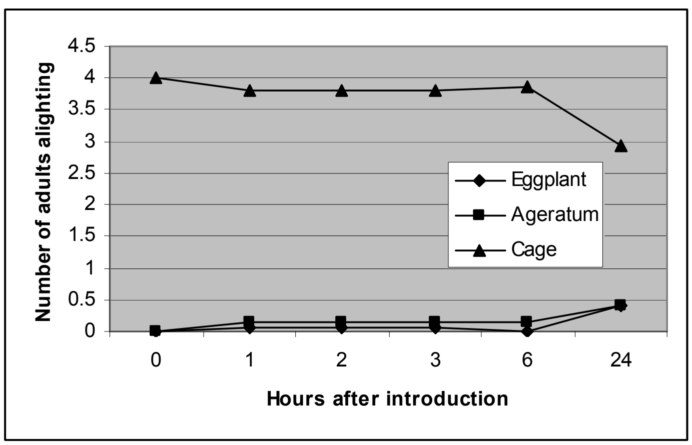


Fig. 3. Number of cutworm adults alighting on *Ageratum conyzoides* and eggplant in host-finding bioassays (4 female adults per cage).

Larval behavior

Larval dispersion was significantly rapid on oregano (*C. aromaticus*), chives (*Allium schoenoprasum* L.) and lemon grass (*C. citratus*), completely without any larvae 24 h after introduction, and about 5% on lemon grass (Table 2). However, a significant and major proportion of the cutworm larvae stayed on marigold and sweet basil (48- 53%). These herbs may be further evaluated for its trap crop potential, although it will require the application of an insecticide that is compatible with Trichogramma in order to maintain a sustainable cropping system.

Table 2. Behavior of cutworm larvae (3rd instar) on selected plants.

	Number of larvae remaining on plant											
Plant	**0 h**		**1 h**		**2 h**		**3 h**		**6 h**		**24 h**	
Marigold	100	a	100	a	86.7	bc	74.7	c	73.3	b	53.3	b
Sweet basil	100	a	100	a	81.3	cd	72	c	72	b	48	b
Oregano	100	a	100	a	100	a	88	b	60	bc	0	d
Chives	100	a	100	a	92	ab	88	b	50.7	cd	0	d
Lemon grass	100	a	92	a	70.7	de	61.3	cd	53.3	cd	5.3	d
Eggplant	100	a	66.7	b	60	e	52	d	40	d	20	c

Larval development and survival.

Lemon grass, eggplant leaves and Ageratum leaves proved toxic to cutworm larvae, followed by oregano (80% mortality) although eggplant fruit sustains larval growth and development (Table 3). This is the reason why cutworm is a pest of eggplant in many parts of the Philippines. Larval survival was highest on sweet basil, *Mimosa pudica* and marigold. However, abnormal pupae developed from larvae fed with *M. pudica* and *I. triloba* and marigold. Thus, it would be necessary to spot treat marigold borders or strips for cutworm larvae. *Ageratum conyzoides* can be maintained in weed borders, as it has flowers which could attract natural enemies while being toxic to larvae that may be dispersed on its leaves.

Natural enemies such as *Diadegma insulare*, hoverflies are attracted to wildflowers as nectar sources (Idris and Grafius, 1995; Hickman and Wrattens 1996; Jones and Gillett 2005; Nicholls et al 2001;Zhou et al 1992).

Table 3. Survival (days) of common cutworm larvae fed with leaves and stems of selected vegetables, herbs and weeds associated with eggplant.

Plant	**Larva, days ± SD**		**Larval Mortality (%)**	**Normal Pupa (%)**	**Abnormal Pupae (%)**
Pechay	15.2	± 0.8 b	0	96	4
Eggplant (leaves)	3.9	± 0.9 e	100	-	-
Eggplant (fruit)	15.0	± b	36	78	12
Sweet basil	12.5	± 2.3 c	10	90	0
Marigold	12.5	± 0.8 c	20	64	16
Oregano	8.5	± 10.3 d	80	16	4
Chives	19.2	± 3.2 a	40	60	0
Lemon grass	1.7	± 0.9 f	100	-	-
Commelina benghalensis L.	16.4	± 6.4 b	40	60	0
Cleome rutidosperma (DC)	15.2	± 3.9 b	28	72	11
Ageratum conyzoides L.	6.2	± 2.0 de	100	-	-
Mimosa pudica L.	15.3	± 4.3 b	10	40	50
Ipomoea triloba L.	15.5	± 5.7 b	50	25	25

*Based on 25 replications (1 larva per replicate) conducted as blocks of 5 replicates per day for 5 days. Means in a column followed by a common letter are not significantly different at 0.01 probability level using GLM and LSD for comparison of treatment means.

CONCLUSION

Host-finding behavior of the common cutworm for eggplant can be disturbed by the presence of some plants, leading to less oviposition activity on eggplant. Some plants have the potential to be good companion plants or intercrops in vegetable gardens while others have the potential as trap crops which could be part of a good push-pull pest management strategy for low input or naturally grown eggplant production. Repellent plants serve to push away the insect pests while trap crops would pull the pests away from the major crop. Larval survival and dispersal behavior provide more information to support the potential of lemon grass, oregano and basil as companion herbs for eggplant. These results can be used for further field trials to develop a sustainable pest management strategy together with biological control agents against cutworm in eggplant production.

ACKNOWLEDGEMENT

This research was supported by the National Crop Protection Center, College of Agriculture, University of the Philippines Los Baños and the Department of Agriculture- Bureau of Agricultural Research.

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