MANAGEMENT OF *LEUCINODES ORBONALIS* GUENEE ON EGGPLANTS DURING THE RAINY SEASON IN INDIA

Sudarshan Chakraborti[1]*, *Pijush Kanti Sarkar*[2]*

Department of Agricultural Entomology
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741252, India

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Abstract: *Leucinodes orbonalis* Guenee (Pyraustidae: Lepidoptera) is a fruit and shoot borer which is the key pest of eggplant (also known as brinjal and aubergine). *L. orbonalis* causes broad-based problems in eggplant cultivation. An effort was made to control the borer during the Indian rainy season, as this is the time when the problem is at its worst. The impact of treatments on natural enemies as well as pollinators was also assessed. Integration of phytosanitation, mechanical control and prophylactic application of neem seed kernel extract (NSKE) exerted a satisfactory impact on the incidence and damage of *L. orbonalis*. After two need-based applications of new generation pesticide molecules like flubendiamide or rynaxypyr or emamectin benzoate, fairly good, healthy yields were produced. A ready-mix formulation (triazophos 40% + cypermethrin 4%), and carbofuran also offered good protection against the borer but both were found highly toxic and unsafe for predators *i.e.* predatory coccinellids and spiders and pollinating bees. Flubendiamide and rynaxypyr appeared comparatively more unsafe for bees than emamectin benzoate, while both allowed a substantial proportion of coccinellids and spiders to survive. Naturolyte, with the active ingredient emamectin benzoate, was found safe for predators and bees and on par with the untreated check.

Key words: bee, coccinellid, *Leucinodes orbonalis*, management, safety, spiders

INTRODUCTION

Leucinodes orbonalis Guenee, is a fruit and shoot borer which is the major problem in the cultivation of eggplants. Yield losses reaching as high as 85–90% have been reported (Patnaik 2000; Misra 2008; Jagginavar *et al*. 2009). Extreme losses were recorded during the Indian rainy season when weather conditions interfere with protection measures. Unsatisfactory protection was reported in many cases. A large quantity of information is available on the management of *L. orbonalis* including management by chemical methods (Chowdhury and Kashyap 1992; Sastrosiswajo 1994; Tonishi *et al*. 2005; Hall 2007; Misra 2008; Lopez *et al*. 2010). Farmers largely follow the chemical method as it produces quick results. High-frequency application is the common scenario. However, these chemicals, in many cases, invited the problems of pesticide resistance, resurgence, secondary pest outbreak, environmental contamination, residual toxicity and toxicity to beneficial organisms and disturbance in homeostasis of natural populations. The new generation of pesticide molecules have been claimed to be effective as well as safer for non-target organisms (Tonishi *et al*. 2005; Hall 2007; Sontakke *et al*. 2007; Misra 2008). In the present study, an effort was made to manage the fruit and shoot borer (FSB) on eggplants during the rainy season. Non-target effects were also assessed.

MATERIALS AND METHODS

Materials

Seeds (*Pusa Purple Cluster* variety), neem seed kernel extract (NSKE) (40%), neem oil (40%), carbofuran (35 G), flubendiamide (480 SC), rynaxypyr (20 SC), emamectin benzoate (5 EC) and a ready-mix formulation (44 EC) (triazophos 40% + cypermethrin 4%), leaves of *Alstonia* scholaris (R. BR.) (*Chhatim* or Devil's tree) (F – Apocynaceae) and *Calotropis procera* (Aiton) (*Akanda* or Giant milk weed) (F – Asclepiadaceae).

Preparation of leaf extract of Alstonia/Calotropis

Five kg fresh leaves were crushed in a blender and added to five litres of hot water (100°C) (1:1 w/v). This mixture was kept in the shade for twenty four hours. A clear extract was obtained by sieving. This extract was used as a stock solution.

Methods

The experiments were conducted during the rainy seasons of 2008 and 2009 in farm fields in the new alluvial zone, North 24 Parganas, West Bengal, India. The plots were set out in a randomized block design with eight treatments including an untreated check. Four replications were done. Each plot measured 4 m x 4 m. Seeds were sown on 2nd June, and 30-day-old seedlings were transplanted at

*Corresponding address:
cs_ento@rediffmail.com, pijushkly@gmail.com

a spacing of 75 cm x 90 cm. Standard agronomic practices were followed to ensure a good crop stand. Treatments: Weekly removal of dead, old leaves and infested twigs as blanket for all treatments including the check. T1 – NSKE @ 7 ml active substance (a.s.)/l at 21 days after transplanting (DAT) + 1st spray of flubendiamide @ 80 g a.s./ha at the first sign of shoot infestation on 30 DAT + NSKE @ 7ml a.s./l on 48 & 55 DAT + 2nd spray of flubendiamide @ 80 g a.s./ha on 63 DAT; T2 – NSKE @ 7 ml a.s./l at 21 DAT + 1st spray of rynaxypyr @ 50g a.s./ha at the first sign of shoot infestation on 29 DAT + NSKE @ 7 ml a.s./l on 47 & 54 DAT + 2nd spray of rynaxypyr @ 50 g a.s./ha on 62 DAT; T3 – NSKE @ 7 ml a.s./l at 21 DAT + 1st spray of emamectin benzoate 12 g a.s./ha at the first sign of shoot infestation on 31 DAT + NSKE @ 7 ml a.s./l on 49 & 56 DAT + 2nd spray of emamectin benzoate @ 12 g a.s./ha on 64 DAT; T4 – spraying of the ready-mix formulation (triazophos 40% + cypermethrin 4%) @ 2 ml a.s./l at 15-day-interval starting from 21 DAT; T5 – carbofuran @ 5 g a.s./plant at 15-day-interval starting from 21 DAT + alternated sprays of neem oil and NSKE @ 7 ml a.s./l at 10-day-interval starting from 21 DAT; T6 – weekly sprays with *Calotropis* leaf extract @ 50 ml/l starting from 15 DAT; T7 – weekly sprays with *Alstonia* leaf extract @ 50 ml/l starting from 15 DAT; T8 – untreated check.

Observations of shoot and fruit infestations were taken from five randomly selected plants/plot, excluding the border ones. A count was taken of the number of holes and larvae per fruit, from 50 randomly selected treated fruit (fruits/treatment). Data on quantitative characters were taken from five randomly selected plants/plot and 50 fruits/treatment for length and diameter of the fruits. Per cent increase in yield over the check was calculated using the following formula:

$$\text{Increase [\%]} = \frac{\text{Treatment yield} - \text{Control yield}}{\text{Treatment yield}} \times 100$$

All the observations were done at 10-day-intervals starting from 21 DAT. Observations of fruits were done at the time of picking. Collected data were then subjected to pooled analysis of variance and compared on the basis of Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Results (Tables 1, 2) indicated that all the treatments were effective against the borer, though varied in their efficacies and were significantly superior to the check. Treatments 1 (flubendiamide + NSKE), 2 (rynaxypyr + NSKE) and 3 (emamectin benzoate + NSKE) were superior to T4 (triazophos 40% + cypermethrin 4%), T5 (carbofuran + NSKE + neem oil), T6 (*Calotropis* leaf extract) and T7 (*Alstonia* leaf extract). T1 recorded only 3.92% shoot and 1.62% fruit infestation and T2 and T3 were similar. T4 and T5 recorded much higher shoot (8.94–9.42%) and fruit damage (6.89–7.52%) and the intensity of infestation was also higher in these two treatments (Table 2). The highest yield of 29.6 t/ha was recorded in T1 closely followed by T2 (28.9 t/ha) and T3 (28.7 t/ha). T4 (27.2 t/ha) and T5 (26.8 t/ha) also produced fairly good yields, but yield loss compared to the best treatment (T1), was also substantial (Loss: T4 – 2.3 t/ha; T5 – 2.8 t/ha). The highest increase in yield over the check was recorded in T1 (65.5%) followed by T2 (65.1%) and T3 (64.5%). T4 and T5 also recorded substantial yield increase, 62.5% and 61.9% respectively but T1, T2 and T3 provided a better cost-benefit ratio (6.89, 6.96 and 6.82, respectively) than T4 and T5. There was more damage of shoots and fruits when the leaf extract treatments were used but both leaf extract treatments showed a superior cost-benefit ratio over the rest of the treatments. The reason for such a good ratio was primarily because of the fact that the leaves were available, free of cost and this helped to keep the input costs lower. The safeness of treatments to predatory coccinellids and spiders and pollinating honey bees was a necessary factor to take into account. T6 (*Calotropis* leaf extract) and T7 (*Alstonia* leaf extract) were the safest treatments, though T3 (emamectin benzoate + NSKE) and T5 (Carbofuran + NSKE + neem oil) were statistically on par with these and the check. T1 (flubendiamide + NSKE) was moderately toxic to both predatory complex and bees, but was superior to the ready-mix formulation (T4). Carbofuran was applied in the soil and this treatment did not receive any foliar application of synthetic pesticide which could cause high mortality of natural enemies and bee populations. Such an application explains why the treatment did not produce many adverse effects on non-targeted organisms. It appeared that integration of the components like phytosanitation, weekly clipping of infested parts and spraying of NSKE/neem oil (assumed as a repellent) produced a cumulative effect to reduce the adult density in field. The reduction, in turn, kept the egg density and hence the borer population at lower levels. The borers were unable to overcome the impact of early assault (application of the pesticides like flubendiamide or rynaxypyr or emamectin benzoate at the initiation of infestation), and to make a heavy population build up. The back up spray (2nd spray) definitely contributed to the inability of the borers to make a heavy population build up. Tonishi *et al*. (2005) and Jagginavar *et al*. (2009) reported that flubendiamide was highly effective against lepidopterans and safe to non-target organisms. Hall (2007) claimed that flubendiamide was safe for coccinellids, predatory mites, parasitoids, honey bees and bumble bees and is a fast-acting pesticide with good residual activity against a broad spectrum of lepidopterans. Emamectin benzoate showed good ovicidal, larvicidal and adulticidal activity against *Helicoverpa zea* (Boddie) (Lopez *et al*. 2010). Rynaxypyr and flubendiamide gave a 87–90% reduction in eggplant fruit damage and rynaxypyr and flubendiamide were safe for natural enemies (Misra 2008). Both, *Calotropis* and *Alstonia* are known to contain several alkaloids and glycosides (Phillipson *et al*. 1987; Sen *et al*. 1992; Salim *et al*. 2004; Kartikar and Basu 1994; Kam and Choo 2004; Ramos *et al*. 2006; Lhinhatrakool and Sutthivaiyakit 2006; Cai *et al*. 2008; Oigiangbe *et al*. 2010; www.botanical.com; www.nast.ph/index) and for this reason, they show repellency, antifeedancy and toxicity. Moursy (1997), Singh *et al.* (2005) and Ramos *et al*. (2006) had reported ovicidal and larvicidal action of *Calotropis procera* leaves against

Table 1. Effect of the treatments on the infestation and damage of *L. orbonalis* Guenee

Treatment	Mean of shoot infestation [%]	Mean of fruit infestation [%]	Mean No. of holes/fruit	Mean No. of larvae/fruit
T1	3.92 (11.39) a	1.62 (7.27) a	0.32 (3.14) a	0.27 (2.98) a
T2	3.74 (11.09) a	2.12 (8.54) a	0.38 (3.16) a	0.25 (2.83) a
T3	4.56 (12.25) a	2.54 (9.10) a	0.89 (5.13) a	0.24 (2.81) a
T4	8.94 (17.36) b	6.89 (15.12) c	2.62 (9.28) c	1.84 (7.81) b
T5	9.42 (17.85) b*	7.52 (15.89) c	2.73 (9.46) c	1.92 (7.94) b
T6	46.43 (43.05) b**	69.64 (56.54) d	5.84 (13.94) d	4.38 (12.07) c

*figures ending with same letter in a column did not differ significantly on the basis of DMRT at 5% level of significance
**figures in parentheses are arcsine √ p transformations

Table 2. Effect of the treatments on the physical parameters and yield of eggplant

Treatment	Mean shoots/ plant	Mean fruit length [cm]	Mean fruit diameter [cm]	Mean fruit number/plant	Mean yield [t/ha]	Mean increase in yield over check [%]	Cost-benefit ratio
T1	19.2 (25.99) a	12.8 (20.96) a	3.8 (11.24) a	42.5 (40.69) a	29.6 a	65.5	6.89
T2	19.8 (26.25) a	12.6 (20.79) a	3.7 (11.09) a	42.8 (40.76) a	28.9 a	65.1	6.96
T3	19.4 (26.13) a	12.6 (20.79)a	3.7 (11.09) a	41.7 (40.22) a	28.7 a	64.5	6.82
T4	17.3 (24.58) b	10.7 (19.09) b	3.1 (10.14) b	36.5 (37.17) b	27.2 b	62.5	2.12
T5	16.8 (24.20) b*	10.8 (19.19) b	3.1 (10.14) b	36.9 (37.41) b	26.8 b	61.9	2.01
T6	10.9 (19.28) c**	6.2 (14.42) c	1.6 (7.27) c	20.4 (26.85) c	10.2 c	–	–

*figures ending with same letter in a column did not differ significantly on the basis of DMRT at 5% level of significance
**figures in parentheses are arcsine √ p transformations

Table 3. Effect of the treatments on the natural enemy-complex and pollinators in the eggplant ecosystem

Treat-ment	Mean number of ^{m}coccinellids/plant				Mean number of ^{n}spiders/plant				Mean number of honey bees/ plot		
	30 DAT	50 DAT	70 DAT	90 DAT	30 DAT	50 DAT	70 DAT	90 DAT	50 DAT	70 DAT	90 DAT
T1	5.9 a	4.8 a	5.8 a	6.2 a	3.6 a	4.1 a	5.3 a	5.1 a	8.2 a	9.4 a	8.7 a
T2	6.2 a	5.1 a	5.9 a	6.4 a	4.2 da	4.2 a	5.2 a	5.6 ac	9.1 a	10.4 a	8.9 a
T3	6.9 a	7.4 c	8.1 c	8.9 c	5.2 d	5.8 c	6.4 c	6.1 c	13.8 c	17.7 b	17.4 c
T4	1.6 b	0.2 b	0.4 b	0.3 b	0.4 b	0.2 b	1.6 b	1.5 b	4.5 b	5.1 c	4.1 b
T5	6.7 a	7.1 c	7.9 c	8.1 c	2.1 c	5.8 c	5.9 ca	6.2 c	12.8 c	14.6 d	16.4 c
T6	6.8 a*	7.3 c	8.2 c	8.3 c	4.6 d	5.9 c	6.2 c	6.4 c	14.5 c	18.2 b	17.1 c

*figures ending with same letter in a column did not differ significantly on the basis of DMRT at 5% level of significance
DAT – days after transplanting
^{m} 4 spp. of coccinellids
^{n} 6 spp. of spiders

dipterans while Elimam *et al*. (2009) claimed that leaf extracts of *C. procera* showed remarkable larvicidal, adult emergence inhibition, repellent and oviposition deterrent effect against different dipteran larval instars. Oigiangbe *et al*. (2007a, 2007b) found that aqueous and methanolic extracts of leaf and bark of *Alstonia boonei* significantly reduced larval survival and adult emergence and also disrupted growth of *Maruca vitrata* Fab. and *Sesamia calamistis* Hamson. Efficacy of the extracts of *Alstonia* and *Calotropis* leaves, as observed in the present study, can be attributed to their alkaloid constituents. Considering all aspects of the treatments, the emamectin benzoate - NSKE combination was the most rational treatment for sustainable management of the fruit and shoot borer problem on rainy season eggplant. *Alstonia* and *Calotropis* extracts showed promising results against *L. orbonalis* and needs to be investigated further.

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