Pest Management in Horticultural Ecosystems
Vol. 25, No.2 pp 172-177 (2019)

Efficacy of sweet flag formulation against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenée (Crambidae: Lepidoptera) and effect on egg parasitoids, *Trichogramma* spp.

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ABSTRACT: An EC formulation of sweet flag (*Acorus calamus*) was tested for insecticidal activity against brinjal shoot and fruit borer, *Leucinodes orbonalis*. All the concentrations of formulation imparted an oviposition deterrence in the range of 48.85±2.86 to 56.79±1.50 per cent. The highest reduction in hatchability of 91.11 per cent was observed in 8.0 per cent concentration of Sweet flag EC. The 8.0 per cent concentration of formulation resulted in a mortality of 79.98 per cent on neonate larvae. Per cent pupation and adult emergence was also low in 8.0 per cent concentration. The increase in concentration of Sweet flag EC resulted in a decrease in per cent parasitisation as well as emergence rate of *Trichogramma pretiosum* and *T. chilonis*.

Keywords: Sweet flag EC, *Leucinodes orbonalis*, oviposition deterrence, *Trichogramma pretiosum and T. chilonis*

INTRODUCTION

Brinjal, *Solanum melongena* L. originated in India (Patil and Mane, 2013). India is the second largest producer of brinjal after China and is grown extensively all over the country throughout the year (Hanur *et al.*, 2014; Manasa *et al.*, 2016). Insect pests act as the major limiting factor for accelerating brinjal yield. The shoot and fruit borer, *Leucinodes orbonalis* Guenée is one of the key pests, which is attributed as the main reason for yield loss (Srinivasan, 2008; Tiwari *et al*., 2011; Pareet and Basavangoud, 2012; Tripathi, 2016). Insecticides are used indiscriminately to produce damage free marketable fruits of brinjal (Srinivasan, 2008). which leads to development of resistance in pests, adverse effect on non-target organisms and residue of insecticides in food commodities (Kranthi *et al*., 2002). In brinjal, development of safe and eco-friendly method of insect pest management is necessary. In nature many plants have shown insecticidal properties and hence these plant derived pesticides have been receiving global attention (Alves *et al*., 2009: Shinthiya and Razak, 2017). Based on the aforesaid issues, the present experiment was carried out to evaluate the efficacy of different concentrations of a botanical pesticide derived from sweet flag (*Acorus calamus*) on *L. orbonalis*.

MATERIALS AND METHODS

Oviposition deterrent activity of Sweet flag EC formulation

The Sweet flag EC formulation was evaluated at four different concentrations (1, 2, 4 and 8 per cent) in separate plastic containers (7.5 x 11 cm). Black coloured cotton cloths were used for the oviposition, which was treated with respective concentrations and were replicated thrice. Untreated checks as well as treatments with Tween 20 and Cyclohexane were kept along with the other treatment in completely randomized design. One pair of freshly emerged *L. orbonalis* adults were released into the container. Observations were recorded on third day after release and per cent oviposition was calculated.

Ovicidal action of Sweet flag EC formulation on eggs of *L. orbonalis*

Different concentrations of Sweet flag EC formulation were assayed by using standard direct spray method to evaluate ovicidal effect on *L. orbonalis* eggs. The cotton cloths with eggs of uniform age were taken from laboratory cultures and the number of eggs in each cloth was counted. The different concentrations were sprayed with the help of atomizer over the eggs of *L. orbonalis*

Table 1. Effect of Sweet flag EC formulation on ovipositional activity of *Leucinodes orbonalis*

Treatment	Per cent oviposition deterrence* Mean±SD
Sweet flag EC 1%	51.62±2.08[a]
Sweet flag EC 2%	52.50±1.22[a]
Sweet flag EC 4%	48.85±2.86[a]
Sweet flag EC 8%	56.79±1.50[a]
Tween 20	9.32±6.14[b]
Cyclohexane	16.68±3.35[b]
Control	0.63±0.00[c]
SEd	2.49
CD (0.05)	5.35

Each value is an average of three replicates; means followed by a common alphabet are not significantly different (P=0.05)

Table 2. Effect of Sweet flag EC formulation on growth and development of *Leucinodes orbonalis*

Treatment	Larval mortality* (%)	Pupation* (%)	Adult emergence* (%)	Pupal: Adult conversion ratio
Sweet flag EC- 8.0%	79.98[a] (63.42)	20.02[d] (26.58)	15.22[d] (22.95)	1:0.57
Sweet flag EC- 4.0%	72.29[a] (58.30)	27.71[c] (32.08)	17.43[d] (24.67)	1:0.69
Sweet flag EC- 2.0%	58.13[b] (49.69)	41.87[b] (40.31)	27.28[c] (31.48)	1:0.71
Sweet flag EC- 1.0%	32.78[c] (34.93)	67.22[a] (54.55)	54.79[b] (47.76)	1:0.82
Untreated control	27.41[c] (31.57)	72.59[a] (58.43)	62.56[a] (52.28)	1:0.86
SEd	1.28	1.28	1.12	
CD (P=0.05)	2.73	2.73	2.39	

*Mean of four replicates; Figures in parentheses are arcsine transformed values; In column, means followed by the common alphabet(s) are not significantly different by LSD (P=0.05)

with three replications in completely randomized design. All the treated cloth pieces containing eggs of *L. orbonalis* were air dried in a shaded condition and kept separately in petri plates and kept in room temperature. Observations were made on every day for a week. The per cent mortality was calculated to find out the efficient concentration of Sweet flag EC formulation against eggs of *L. orbonalis*.

$$\text{Reduction in egg viability} = \frac{E_t - E_h}{E_t} \times 100$$

Where E_t is the total number of eggs kept for hatching and E_h = Total number of eggs hatched

The corrected mortality was worked out by using the following formula (Abbott, 1925):

$$\text{Corrected per cent mortality} = \frac{P_0 - P_c}{100 - P_c} \times 100$$

Where P_0 is the observed mortality in treatment and P_c is the observed mortality in untreated control.

Insecticidal action of Sweet flag EC formulation on neonate larvae of *L. orbonalis*

A laboratory experiment was conducted to assay the toxicity of Sweet flag EC formulation on neonate larvae of *L. orbonalis*. Brinjal fruit were dipped for 10 minutes in four different concentrations (1, 2, 4 and 8 per cent) of Sweet flag EC, shade dried and placed in plastic cups (10 cm diameter x 8 cm height). Ten neonate larvae were released in to each fruits. An untreated control also maintained and all were replicated four times under completely randomized design. Data on larval mortality was calculated based on per cent pupation. Data on adult emergence and pupal adult conversion ratio were also recorded.

Effect of Sweet flag EC formulation on egg parasitoids *Trichogramma* spp.

Effect of different concentrations of Sweet flag EC formulation to *Trichogramma* spp. were evaluated along with control in CRD with three replications. The egg parasitoids *T. pretiosum* and *T. chilonis* were obtained from Bio-control laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India. In the first experiment the parasitized egg cards were treated with different concentrations of Sweet flag EC using hand atomizer and for untreated check, distilled water was used. Treated egg cards were shade-dried for 10 minutes and kept in test tube of 10 x 1.5 cm size for observation. Observations were made on the number of adult parasitoids emerged after 72 hours of treatment and per cent adult emergence was worked out.

In the second experiment, *Corcyra* egg card (6x1 cm^2) was sprayed with different concentrations of Sweet flag EC formulation and treated egg cards were cut into bits of 1 cm^2. One treated bit of *Corcyra* card and one bit of untreated parasitized.

RESULTS

The oviposition deterrent activity of Sweet flag EC was evaluated by comparing the number of eggs laid on the control and each treatment. The oviposition deterrent activity of all the different concentrations was significantly different from control but not among the different concentrations (Table 1). All the concentrations showed oviposition deterrence in the range of 48.85±2.86 to 56.79±1.50 per cent. The highest oviposition deterrence was showed by 8.0 per cent concentration (56.79±1.50%).

The experiment conducted to find out ovicidal action of Sweet flag EC formulation showed a significant reduction in egg hatchability (Fig. 1). The per cent egg hatchability was inversely proportional to the concentration of insecticide. The highest reduction in hatchability of 91.11 per cent was observed in 8.0 per cent concentration of Sweet flag EC followed by 67.78 per cent in 4.0 per cent concentration. Percentage reduction in egg hatchability in 1.0 per cent and 2.0 per cent concentration was 33.33 and 44.44 per cent respectively.

The bioassay conducted to find out the insecticidal activity of different concentrations of Sweet flag EC formulations are furnished in Table 2. It showed that 8.0 per cent concentration of Sweet flag EC formulation had a significant role in mortality of neonate larvae of *L. orbonalis*. The 8.0 per cent concentration resulted in a mortality of 79.98 per cent on neonate larvae followed by 4.0 per cent with the mortality of 72.29 per cent. The different concentrations had an impact on per cent pupation also, with the least in treatment with 8 per cent Sweet flag EC (20.02 per cent) followed by 4.0 per cent with 27.71 per cent. The adult emergence was the least in 8.0 per cent (15.22 per cent), which is on par with 4 per cent concentration. The adult pupation conversion ratio was highest in control (1:0.86) followed by 1.0 per cent concentration (1:0.82) and least in 8.0 per cent concentration (1:0.57).

The effect of Sweet flag EC formulation on parasitisation and emergence of *T. pretiosum* and *T .chilonis* is presented in the Table 3. The result revealed that the different concentrations had

Table 3. Effect of Sweet flag EC formulation on *Trichogramma pretiosum* and *Trichogramma chilonis*

Treatment	*T. pretiosum*		*T. chilonis*	
	Parasitisation (%)	Emergence (%)	Parasitisation (%)	Emergence (%)
Sweet flag EC- 8%	0.00 (0.63)^{e}	0.00 (0.52)^{e}	0.00 (0.63)^{f}	0.00 (0.52)^{c}
Sweet flag EC- 4%	0.00 (0.63)^{e}	0.80 (5.14)^{d}	0.00 (0.63)^{f}	1.30 (5.43)^{c}
Sweet flag EC- 2%	27.53 (31.64)^{d}	19.64 (26.30)^{c}	30.70 (33.63)^{d}	19.97 (26.53)^{b}
Sweet flag EC- 1%	69.01 (56.18)^{c}	28.70 (32.37)^{b}	79.17 (62.85)^{e}	30.47 (33.50)^{b}
Tween 20	90.89 (72.46)^{b}	58.43 (49.86)^{a}	94.49 (76.44)^{b}	59.81 (50.69^{a}
Cyclohaxane	93.38 (75.13)^{a}	58.06 (49.65)^{a}	89.78 (71.37)^{c}	60.36 (50.98)^{a}
Untreated control	94.30 (76.21)^{a}	64.90 (53.67)^{a}	95.88 (78.32)^{a}	68.56 (56.01)^{a}
SEd	0.82	1.33	0.72	2.48
CD(0.05)	1.76	2.86	1.54	5.33

*Mean of three replicates; Figures in parentheses are arcsine transformed values; In column, means followed by the common alphabet(s) are not significantly different by LSD (P=0.05)

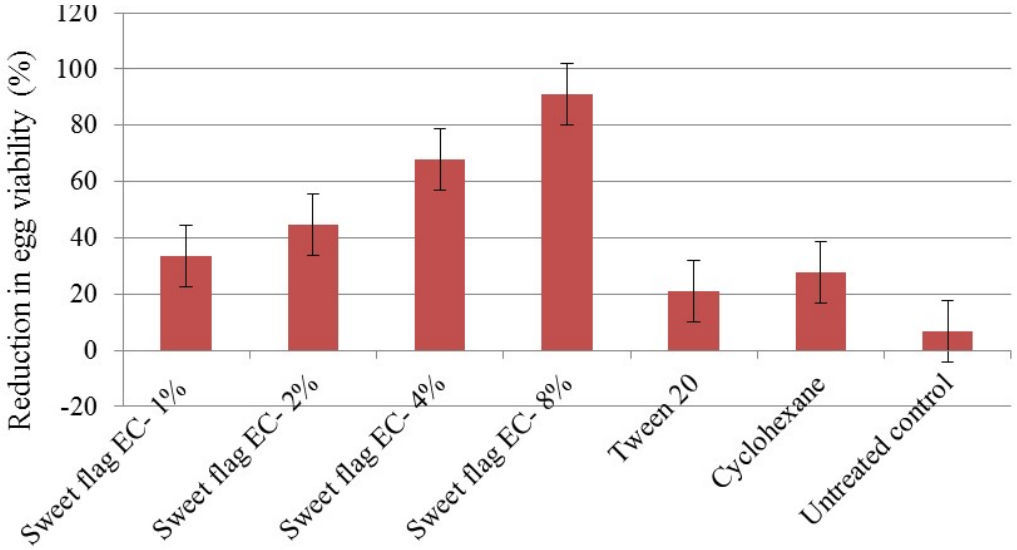

Fig 1. Ovicidal action of Sweet flag EC formulation on eggs of *Leucinodes orbonalis*

an impact on the parasitisation as well as emergence of *T. pretiosum* and *T. chilonis*. The mean adult emergence varied between 0.00 to 68.56 per cent in different treatments for *T. pretiosum* and *T. chilonis*. The different concentrations of Sweet flag EC formulation showed a varying range of effect on *T. pretiosum* and *T. chilonis* on adult emergence, which ranged from 0.00 to 28.70 per cent and 0.00 to 30.47 per cent for *T. pretiosum* and *T. chilonis* respectively. The 1.0 per cent concentration was found to be safer for both parasitisation as well as emergence of trichogrammatids. It showed parasitism of 69.01 and 79.17 per cent in *T. pretiosum* and *T. chilonis* respectively. The emergence from 1.0 per cent treated parasitized eggs was 28.70 and 30.47 per cent for *T. pretiosum* and *T. chilonis* respectively. At 8.0 and 4.0 per cent concentrations of Sweet flag EC formulation the parasitisation and emergence were nil irrespective of species. The parasitisation observed in 2 per cent concentration of Sweet flag EC was 27.53 and 30.70 per cent for *T. pretiosum* and *T. chilonis* respectively. The increase in concentration of Sweet flag EC resulted in a decrease in per cent parasitisation as well as emergence rate of *T. pretiosum* and *T. chilonis*. High concentrations (4% & 8%) were so detrimental that less than 2 per cent parasitisation of either species was observed. All concentrations of Sweet flag EC resulted in less than 31 per cent of emergence of either species.

DISCUSSION

The oviposition deterrence activity of Sweet flag EC formulation did not vary among different concentrations tested but it was significantly deferent from to control. The highest deterrence of 52.79±1.50 per cent was observed in 8.0 per cent Sweet flag EC formulation. The ovicidal action due to 8.0 per cent Sweet flag EC formulation was the highest (91.99 per cent reduction in egg hatchability) in. The aromatic compound present in the Sweet flag formulation might be the reason for deterrence as well as the ovicidal activity. Similarly Yasoda and Natarajan (2007) reported minimum oviposition index of 0.22 and maximum ovicidal action of 62.60 per cent when used aqueous extract of Sweet flag along with neem seed kernel extract against *L. orbonalis*.

Sweet flag EC affected the growth and development of *L. orbonalis* larvae. Sweet flag EC at 8.0 per cent imparted a maximum larval mortality of 79.98 per cent in neonate larvae. The per cent pupation was least (20.02) in 8.0 per cent concentration of formulation. The adult emergence was 15.22 and 17.43 per cent in 8.0 and 4.0 per cent respectively, which was not significantly different. The effect of Sweet flag formulation on growth and development of *L. orbonalis* might be also due to its growth inhibitory effect. Our present study clearly depicts that the Sweet flag EC had an impact on growth and development of *L. orbonalis*. Likewise 90 per cent mortality of variegated cut worm, *Peridroma saucia*, reported by Koul (1987) supports the present observation.

The Sweet flag formulation had some effect on parasitisation and emergence of *Trichogramma* spp. depending on the concentration. The low concentration of the formulation (1%) was safer to egg parasitoid whereas high concentrations (4% and 8%) were detrimental to parasitisation as well as emergence of parasitoid from its host eggs. Sweet flag EC at safe level of 1.0 per cent concentration resulted in 30.47 and 28.70 per cent parasitisation in case of *T. chilonis* and *T. pretiosum* respectively. The reduction in per cent parasitisation as well as emergence rate might be due to growth retardant activity of compounds present in the Sweet flag formulation. There is no report on effect of Sweet flag formulation on parasitisation and emergence of trichogrammatids. Similar studies were conducted by Raguraman and Singh (1999) who reported that botanical insecticide, neem oil had a negative impact on per cent parasitism by *T. chilonis*. Saber *et al.* (2004) also reported 73.3 and 33.76 per cent reduction in emergence rate of *T. cacoeciae* on *Sitotroga cerealella* and *Cydia pomonella* respectively due to neem based formulations.

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MS Received 28 June 2019
MS Accepted 21 September 2019