Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 3182-3185

Received: 17-01-2018
Accepted: 18-02-2018

Rabin Mandi
Bidhan Chandra Krishi Viswavidyalaya Mohanpur, Dist-Nadia, West Bengal, India

Aniruddha Pramanik
Bidhan Chandra Krishi Viswavidyalaya Mohanpur, Dist-Nadia, West Bengal, India

Correspondence
Rabin Mandi
Bidhan Chandra Krishi Viswavidyalaya Mohanpur, Dist-Nadia, West Bengal, India

Effect of eco-friendly pesticides on mortality, growth and development of *Spodoptera litura* (Fab.) in laboratory condition

Rabin Mandi and Aniruddha Pramanik

Abstract
The present experiments were conducted at IPM Laboratory, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, to find out the efficacy and toxicity of some eco-friendly pesticides against cabbage borer, *Spodoptera litura* (Fab.). Among the treatments maximum mortality (91.25%) was noticed in diflubenzurn + deltamethrin 22% SC @ 0.022% at 7th day of observation but at par with that of (91.13%) abamectin 400FS@ 0.02%. The highest growth index (5.00) was noted in untreated control as compared to the lowest growth index (1.03) which was observed in diflubenzurn + deltamethrin 22% SC @ 0.01%. The lowest larval pupal index (1.24) and lowest survival index (0.33) of *Spodoptera litura* was obtained in case of *Bacillus thuringiensis* @ 0.1%. From this study it can be said that among five different pesticides, *Bacillus thuringiensis*, revealed higher susceptibility to *Spodoptera* on the basis of the percent pupation and adult emergence.

Keywords: *Spodoptera litura*, eco-friendly pesticides, food consumption indices, tobacco caterpillar

Introduction

Among the foliage feeding insect *Spodoptera litura*, commonly known as tobacco caterpillar is most destructive polyphagous agricultural lepidopteran pest, which attacks more than 90 plant species in at least 18 families including Cruciferae, Solanaceae, Malvaceae, Fabaceae, that causes severe economic damage to main crops such as cabbage, cauliflower, Brussels sprouts, sugar beet, maize, cotton and tomato (Mehrkhou *et al*. 2012 a,b) [11, 10]. The cabbage borer, *Spodoptera litura* causes economic losses of crops from 25.8-100% based on crop stage and its infestation level in the field (Dhir *et al*. 1992) [4]. To manage the pest, farmer used different kinds of chemical insecticides. Intensive and successive applications of broad spectrum chemical insecticides for insect pest management may cause rush of problems, such as insecticides resistance to different insect, environmental pollution and its results, increase in the costs of insect pest management and mainly, the death of natural enemies. The current trends of modern society towards 'green consumerism' and growing awareness of health and environmental issues associated with the intensive use of chemical pesticides has lead to interest in alternate forms of pest management technique in the world. Hence, to minimize the use of chemical pesticides, there is an important need for find out the safer, alternative crop protectants *ie* eco-friendly pesticides.

The insect like to feed and oviposit on high quality plants (Chen *et al.* 2004, Purudic *et al.* 2005) [2, 12] to ensure the availability of better food for their progeny. Quality and quantity of food consumed by the pest can affect its entire biology, rate of growth, development, reproduction (Khedr *et al*. 2015, Reese 1978) [9, 13]. The growth index emphasizes the importance of both survival and development time in calculating food quality. For making suitable and sustainable management practice of *Spodoptera litura*, knowledge on the larval feeding behaviour, growth, development and host characteristics are very important.

An attempt has been made in the present investigation to find out-

(1) The efficacy of eco-friendly pesticides against *Spodoptera litura* larvae.
(2) To assess the usefulness of indices based on consumption and utilization of eco-friendly pesticides treated cabbage leaves against cabbage borer.

Materials and Methods

The food plant (Cabbage *Brassica oleracea* Var. *capitata*) was grown under field conditions without any insecticidal application at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, W.B. and *Spodoptera litura* larvae were obtained from bio control laboratory, BCKV, Kalyani, W.B. and reared at the laboratory of AICRP on Plant Parasitic Nematodes and IPM Laboratory, Directorate of Research, Kalyani, Bidhan Chandra Krishi Viswavidyalaya, W.B.

Comparative effect of eco-friendly pesticides on the growth and mortality of *Spodoptera litura* (Fab.)

The evaluation was carried out under laboratory condition at 26.53-37.38°C temperature and 48.80-87.77% RH. The fresh cabbage leaves were collected from the field and cut in equal sizes. Then the solution of the different concentration of *Bacillus thuringiensis* 5% WP, abamectin 400FS, spinosad 45% SC, and botanical-NSKE and insect growth regulator (diflubenzuron + deltamethrin) 22% SC, was prepared as mentioned in table-1 and cabbage leaves were dipped in solution for few seconds and kept under shade for drying. Eight hours starved second instar larvae of approximately same size were allowed to feed on the treated leaves for 24 hours. Fresh equal size cabbage leaves were given to larvae at every 24 hours interval and uneaten leaves along with faeces were removed (Waldbauer 1968) [16]. The experiment for each treatment was replicated four times, involving 20 larvae in each replication.

Fresh equal size cabbage leaves were supplied daily to the larva up to pupation. Observation was taken after every 24 hours on the following parameter.

a) Larval mortality
b) Larval period
c) Larval survival (percent)
d) Percent pupation
e) Pupal period
f) Percent adult emergence.

From these observations, the growth indices will be calculated as follows (Deshmukh *et al.*, 1982) [3].

$$\text{i) Growth Index (G.I)} = \frac{\text{Percent pupation}}{\text{Larval period}}$$

$$\text{ii) Larval-pupal Index} = \frac{\text{Av. larval period (days) on untreated check + Av. pupal period (days) on untreated check}}{\text{Av. larval period (days) on treatment + Av. pupal period (days) on treatment}}$$

$$\text{iii) Survival Index} = \frac{\text{The no. of adult emerged from the larva reared on treatment}}{\text{The no. of adult emerged from the larvae reared on untreated check}}$$

Table 1: Treatment details for *Spodoptera litura* (Fab.)

Treatments	Dose (% *a.i.*)
Bacillus thuringiensis 5% WP	0.1
Abamectin 400FS	0.02
Diflubenzuron + deltamethrin 22% SC	0.01
NSKE (Neem Seed Kernel Extract).	2.5
Spinosad 45% SC	0.005
Untreated control	-

The critical difference (CD) at 0.05% level of significance were worked out from the data of percent reduction population of replication before treatment and various days interval after treatment. The data analysed in CRD were subjected to Duncan's Multiple Range Test (DMRT) at 5% level after making angular transformation Gomez and Gomez (1984) [6].

Results and Discussions

Effect of eco-friendly pesticides against *Spodoptera litura* (Fab.) in laboratory condition

To evaluate the toxicity of different insecticides against 2nd instar larvae of *Spodoptera litura* had been conducted in laboratory and relative toxicity of insecticides evaluated on the basis percentage of mortality of treated larvae on different insecticides, are presented in table-2.

Table 2: Effect of eco-friendly pesticides against *Spodoptera litura* (Fab.) in laboratory condition

Treatments	Dose (% *a.i.*)	Mortality % at different days after treatment				Mean
		1 DAT	3 DAT	5 DAT	7 DAT	
Bacillus thuringiensis	0.1	8.75	47.50	60.00	72.50	47.19
		(16.77)^{d}	(43.57)^{ab}	(50.78)^{bc}	(58.49)^{bc}	
Abamectin 400FS	0.02	23.75	58.75	75.00	91.13	62.16
		(29.09)^{bc}	(50.11)^{a}	(60.29)^{a}	(74.51)^{a}	
Diflubenzuron + deltamethrin 22% SC	0.01	45.00	55.00	71.25	91.25	65.63
		(42.12)^{a}	(47.88)^{a}	(57.69)^{ab}	(73.23)^{a}	
Neem Seed Kernel Extract (NSKE)	2.5	17.50	38.75	53.75	68.75	44.69
		(24.45)^{c}	(38.44)^{b}	(47.18)^{c}	(56.06)^{c}	
Spinosad 45% SC	0.005	32.50	52.50	63.75	83.75	58.13
		(34.68)^{b}	(46.51)^{a}	(53.09)^{abc}	(66.41)^{ab}	
Untreated control	0.00	0.00	0.00	0.00	0.00	0.00
		(4.05)^{e}	(4.05)^{c}	(4.05)^{d}	(4.05)^{d}	
SEm±		2.32	2.23	2.53	2.86	
CD at 0.05%		6.89	6.61	7.52	8.51	

* DAT=Days after treatment.
* Figures within parentheses are angular transformed values.
* In a column, means followed by same alphabet are not significantly different (p=0.05) by DMRT.

From the findings it had been recorded that all the treatments were significantly superior over untreated control. Maximum larval mortality 45.00% was recorded in diflubenzuron+ deltamethrin - 22%SC 0.01% on the 1st day of treatment and in the 3rd and the 5th day, maximum mortality 58.75% and 75.00% was recorded in abamectin 400FS @ 0.02%. On the last day 91.25% mortality was recorded from diflubenzuron + deltamethrin 22%SC @ 0.01%, but the lowest population

reduction significantly differed in different day and mortality. But lower mortality in treatment after 1st day was observed in *Bacillus thuringiensis* formulation and in remaining days it was recorded in Neem Seed Kernel Extract.

Based on overall mean of percent mortality at different days after treatment, population reduction ranged from 44.69% to 65.63% which showed significant differences among the treatments. The lowest larval population reduction 47.19% was recorded in NSKE @ 2.5% and highest 65.63% was in diflubenzuron+ deltamethrin 22%SC @ 0.01% and all the treatments were superior than untreated control.

Short term feeding (for 48h) of newly emerged second instar larvae on cucumber leaves treated with neem based insecticides induced upto 20% larval mortality (Shannag *et al.* 2015) [15]. Laboratory studies of *Beauvaria bassiana* and *Bacillus thuringiensis* on different stages of *Spodoptera litura* larvae showed that the early instars were susceptible (Gloriana *et al.* 2000) [5]. Amonkar *et al.* (1985) [1] indicated that the efficacy of different strains of *Bacillus thuringiensis* like *kurstaki*, *aizawi* and *kenyae* against *Spodoptera litura.* According to Zaz (1989) [18], *Bacillus thuringiensis* caused 5.0 - 72.5% larval mortality, 1.25 - 10.0% pupal mortality and 3.8 - 13.8% deformity in the adult stage of *Spodoptera litura* the present study are in conformity with the available literature.

Effect of eco-friendly pesticides on the growth and development of *Spodoptera litura* (Fab.)

The table-3 shows that the growth and development of *Spodoptera litura* larvae on eco-friendly pesticides and some chemicals that acknowledge us the relative susceptibility of the test insect to the treated food. The experiment was carried out to determine the relative performance of eco-friendly pesticides on the growth and development of *Spodoptera litura* under laboratory condition at 26.53 - 37.38ºC and 48.80 - 87.77% RH.

Table 3: Effect of eco-friendly pesticides on the growth and development of *Spodoptera litura* (Fab.)

Treatments	Dose (% *a.i.*)	Larval Period (Days)	Pupal Period (Days)	% Pupation	% adult emergence
Bacillus thuringiensis	0.1	9.50^{b}	4.25^{a}	23.75 (29.09)^{b}	25.83 (30.46)^{b}
Abamectin 400FS	0.02	10.25^{b}	3.75^{a}	12.50 (20.61)^{b}	29.17 (32.63)^{b}
Diflubenzuron + deltamethrin 22% SC	0.01	9.75^{b}	4.25^{a}	10.00 (18.43)^{b}	37.50 (37.50)^{b}
Neem Seed Kernel Extract (NSKE)	2.5	8.75^{b}	3.50^{a}	26.25 (30.75)^{b}	27.92 (31.77)^{b}
Spinosad 45% SC	0.005	9.75^{b}	4.00^{a}	23.75 (29.09)^{b}	25.83 (30.46)^{b}
Untreated control	0.00	12.00^{a}	3.25^{a}	70.00 (60.59)^{a}	79.27 (62.99)^{a}
SEm±		0.50	0.37	4.22	2.38
CD at 0.05%		1.49	1.11	12.53	7.07

* Figures within parentheses are angular transformed values.

* In a column, means followed by same alphabet are not significantly different (p=0.05) by DMRT

Larval period

The result (table-3) showed that highest larval period (10.25 days) was obtained in abamectin 400FS @ 0.1% followed by 9.75 days in diflubenzuron + deltamethrin 22% SC @ 0.01% and spinosad 45%SC @ 0.005% respectively and the lowest larval period was 8.75 days in NSKE @ 2.5%. All the treatments were significantly at par with each other except untreated control (12.00 days). Similar result also observed by Shahout *et al.* (2011) [14] that the larva duration was significantly decreased when the larvae fed on cabbage leaves and it was about (15.55) days.

Pupal period

From the table-3 it was observed that the highest pupal period (4.25 days) was found in both *Bacillus thuringiensis* @ 0.1% and diflubenzuron + deltamethrin 22%SC 0.01% followed by 4.00 days in spinosad 45%SC @ 0.005% where as 3.75 days was observed in untreated control. Shahout *et al.* (2011) [14] also reported that the pupal duration was affected (7.54 days) when the larvae fed on cabbage leaves.

Percent pupation

It is evident from table-3 that the percent pupation of *Spodoptera litura* ranged from 10.00% to 26.25% and significantly lower than that of untreated control 70.00%. Among the treatments, highest percent pupation 26.25% was recorded in NSKE @ 2.5% and lowest 10.00% was obtained from diflubenzuron + deltamethrin - 22% SC @ 0.01%. All the treatments were significantly different from untreated control. Xue *et al*. (2010) [17] also found that the pupae developed faster on cowpea than on Chinese cabbage.

Adult emergence

The table-3 revealed that the adult emergence ranged from 25.83 to 37.50% and all the treatments were significantly lower than that of untreated control (79.27%). Lowest 25.83% adult emergence was recorded in both *Bacillus thuringiensis* @ 0.1% and spinosad 45%SC @ 0.005%. In the present findings larval and pupal period significantly reduced from untreated control. All the treatments adversely affected the pupation and adult emergence of *Spodoptera litira*. The prolongation of pupal period in *Bacillus thuringiensis* recorded in the present study was more or less similar to those reported by (Gupta and Rana 1991) [8] on *Spodoptera obliqua*.

Growth Index

Higher growth index (5.00) was noted in untreated control which highly differed from all other treatments. The highest index in the treatment was 3.03 and lowest 1.03 was in NSKE @ 2.5% and diflubenzuron + deltamethrin 22%SC at 0.01% respectively. According to Greenberg *et al.* (2001) [7] the higher growth index of *Spodoptera litura* on untreated cabbage leaves indicated better food quality of the plant.

Larval-pupal Index

It is evident from table-4 that the larval pupal index ranged

from 1.24 to 1.49 with highest index in diflubenzuron + deltamethrin 22%SC at 0.01%, followed by 1.37 in abamectin 400FS @ 0.005% and lowest index 1.24 was recorded in *Bacillus thuringiensis* @ 0.1%.

Table 4: Impact of eco-friendly pesticides on growth indices of *Spodoptera litura* (Fab.)

Treatments	Dose (% *a.i.*)	Growth Index	Larval Pupal Index	Survival Index
Bacillus thuringiensis	0.1	(2.53)[b]	1.24	0.33
Abamectin 400FS	0.02	(1.24)[c]	1.37	0.37
Diflubenzuron + deltamethrin - 22% SC	0.01	(1.03)[c]	1.49	0.47
Neem Seed Kernel Extract (NSKE)	2.5	(3.03)[b]	1.29	0.35
Spinosad 45% SC	0.005	(2.48)[b]	1.29	0.33
Untreated control	0.00	(5.00)[a]		
SEm±		0.24		
CD at 0.05%		0.70		

* In a column, means followed by same alphabet are not significantly different (p=0.05) by DMRT

Survival Index

Table-4 illustrated that the highest survival index 0.47 was obtained from diflubenzuron + deltamethrin 22%SC at 0.01%, followed by 0.37 in abamectin 400FS @ 0.02% and 0.35 in NSKE @ 2.5%. However, lowest survival index 0.33 was recorded in *Bacillus thuringiensis* @ 0.1% and spinosad 400 FS @ 0.005%.

Conclusion

From the findings among the eco-friendly pesticides IGR, diflubenzurn + deltamethrin 22% SC recorded the maximum mortality and highest Growth Index but the lowest larval pupal index and lowest survival index of *Spodoptera litura* was obtained in *Bacillus thuringiensis* @ 0.1%. So this study can said that among the five different pesticides, *Bacillus thuringiensis*, revealed higher susceptibility to *Spodoptera* on the basis of the percent pupation and adult emergence.

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