International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 1939-1941

Received: 01-03-2019
Accepted: 03-04-2019

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Bio-efficacy of multiple insecticides against shoot and fruit borer of brinjal (*Leucinodes orbonalis* Guenee) and their impact on fruit yield

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Abstract
The experiment on the bioefficacy of six insecticidal treatments comprising Dimethoate 20% + Cypermethrin 3% EC at four different doses *viz*., 114.8, 123.6, 132.5 and 141.3 g a.i./ha along with single dose of Dimethoate 30% EC (200g a.i./ ha) and Cypermethrin 25% EC (50 g a.i./ ha) against shoot and fruit borer, *Leucinodes orbonalis* was conducted at I.G.K.V., Raipur during *Rabi*, 2017. Based on the two spray, it is concluded that the application of T4, Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha found to be the most effective treatment. It was followed by T3, Dimethoate 20% + Cypermethrin 3% EC @ 132.5 g a.i./ha in terms of mean mortality of shoot and fruit borer, *Leucinodes orbonalis* and also recorded higher marketable yield.

Keywords: Brinjal, mortality, *Leucinodes orbonalis,* bio-efficacy

Introduction
The eggplant or brinjal (*Solanum melongena* L.) is one of the most important solanaceous vegetables in South-East Asian countries. India ranks second and China ranks first in the production of brinjal and accounting for almost 50% of the world's area under its cultivation (Alam *et. al*., 2003) [1]. It contains vitamins A, B and C and has ayurvedic medical properties as well, the fruit being good for diabetic patients. It is grown throughout the year under irrigated condition and is attacked by a number of insect pests right from the nursery stage till harvesting. Several biotic and abiotic factors are responsible for lowering down the yield of brinjal. Among them, insect pests are the important factors which greatly affect the quality and productivity of brinjal crop. Among the insect pests infesting brinjal, the major ones are shoot and fruit borer, *Leucinodes orbonalis* Guen., white fly, *Bemisia tabaci* Genn., leaf hopper, *Amrasca bigutella bigutella* Ishida, *Epilachna* beetle, *Henosepilachna vigintioctopunctata* Fab (Regupathy *et al*., 1997) [7]. Among these, the brinjal fruit and shoot borer is considered to be the main constraint as it damages the crop to a great extent throughout the year both at vegetative and reproductive stage. Mall *et al.* (1992) [4] reported that the shoot and fruit borer (on shoot) were more prevalent during vegetative phase of the crop. However, Singh *et al*. (2000) [8] reported that the borer infestation was 78.66% on top shoots in vegetative phase and then shifted to flowers and fruits with infestation reaching 66.66% in fruiting phase. The yield loss due to this pest is to the tune of 70-90% (Reddy *et. al.* 2004) [6]; 4.33 to 6.54 % shoot damage and 52.3% fruit damage having been recorded irrespective of the planting month (Tripathy *et. al.* 1997) [9]. The small moth with dirty whitish wings and speckled marking lays eggs on young leaves/ flowers/ calyx of the fruits. After hatching (with in 6 hrs) the young larvae bores into the petiole/ midrib of leaves/ growing shoots/ flower buds/ fruits and closes the bore hole with frays, after entering it will feed inside the midribs/ flower/ ovary of flower and in the pulp of fruit. The damaged shoots and the damaged flowers droop down and the damaged fruits get rotten from inside. The entry hole on the fruit is not visible as this is covered with frays and only the faded depression of entry hole is seen. The large one or more round exit holes are visible on the fruits. Such fruits lose their market value.

Although insecticidal control is one of the common means against the fruit borer, many of the insecticides applied are not effective in the satisfactory control of this pest. Brinjal being a vegetable crop, use of chemical insecticides will leave considerable toxic residues on the fruits. Beside this, sole dependence on insecticides for the control of this pest has led to insecticidal resistance by the pest (Natekar *et al*., 1987; Harish *et al*., 2011) [5, 2].

The pesticides molecules of new generation have been claimed to be effective as well as safer for non-target organism. Realizing serious pest status of the shoot and fruit borer, few promising, and widely recommended insecticides were incorporated in the present investigation. Non-target effects were also assessed.

Materials and Methods

The Experiments was carried out under field conditions at the Horticulture farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, during *rabi* 2017-18. Bioefficacy of six insecticidal treatments comprising Dimethoate 20% + Cypermethrin 3% EC at four different doses viz., 114.8, 123.6, 132.5 and 141.3 g a.i./ha respectively has been tested against brinjal shoot and fruit borers along with single dose of Dimethoate 30% EC (200g *a.i.*/ ha) and Cypermethrin 25% EC (50 g *a.i.*/ ha) were sprayed with an untreated control check was shown in Randomized Block Design. There were three replications with 4 x 4.5 meter plot size. The plant spacing between row to row and plants to plant were maintained 60 cm and 60 cm, respectively.

Pre-treatment population of insect be recorded one day before spray while post-treatment observation made after 1, 3, 7, 10 and 15 days after spraying five plants randomly selected from each plot to work out the % reduction in the insect population over control using Henderson & Tilton formula for statistical analysis.

Henderson-Tilton's formula

$$\text{Corrected \%} = \left(1 - \frac{\text{n in Co before treatment} * \text{n in T after treatment}}{\text{n in Co after treatment} * \text{n in T before treatment}}\right) * 100$$

Where: n = Insect population, T = treated, Co = control

Two sprays of each treatment were applied. Fruits were harvested from each plot separately and yield per plant each picking was recorded in kg. Total yield was worked out by adding the yield of each picking. The yield per plot was converted to quintals per hectare.

Results and Discussion

None of the shoots of eggplant was damaged due to *L. orbonalis*. It may be due to characters of variety used in the experiment, which had many hairy, spines like structure throughout the shoot region. Probably, this characteristic of the host plant is unattractive to the *L. orbonalis* for oviposition, feeding or shelter (Antixenosis mechanism of Host Plant Resistance). However, fruit infestation was started right from the fruit initiation and it was in increasing trend up to the final harvest.

The data presented in Table-1 revealed that during Rabi 2017; all the treatments were found significantly superior to untreated control. The highest mean reduction in fruit damage was recorded in case of two sprays of T4, Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha which caused 85.3 % mean mortality after first spray at 1, 3, 7, 10 and 15 days after spray and 74.36 % mean mortality after second spray at 1, 3, 7, 10 and 15 days after spray and overall mean was calculated 79.83% mortality after first and second spray during Rabi 2017. It was followed by T3, Dimethoate 20% + Cypermethrin 3% EC @ 132.5 gm a.i./ha which caused 77.54 % mean mortality after first spray at 1, 3, 7, 10 and 15 days after first spray and 69.14 % mean mortality after second spray at 1, 3, 7, 10 and 15 days after spray and overall mean was calculated 73.34 % mortality after first and second spray which was found to be at par with other two doses of Dimethoate 20% + Cypermethrin 3% EC @ 123.6 g a.i./ha (T2), Dimethoate 20% + Cypermethrin 3% EC @ 114.8 g a.i./ha (T1) and single dose of Dimethoate 30% EC @ 200g *a.i.*/ ha (T5) which caused 69.20, 63.14 and 58.70 percentage mean mortality respectively after first and second spray at 1, 3, 7, 10 and 15 days against the brinjal shoot and fruit borer (Table-1). Comparatively low mortality per cent of brinjal shoot and fruit borer was recorded from Cypermethrin 25% EC @ 50 *a.i.*/ ha (T6) treated plots after first and second spray at 1, 3, 7, 10 and 15 days after spray and no mortality was observed in untreated check plots (Table-1).

At the end of the experiment, the marketable fruit yield (Table 2) of all the pickings was added and transformed into quintals on hectare basis. Among all the treatments T4, Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha proved to be the best in producing highest marketable yield (228.00q/ha) followed by T3, Dimethoate 20% + Cypermethrin 3% EC @ 132.5 gm a.i./ha (216.00q/ha) at par with other two doses of Dimethoate 20% + Cypermethrin 3% EC @ 123.6 g a.i./ha (T2) (209.00q/ha), Dimethoate 20% + Cypermethrin 3% EC @ 114.8 g a.i./ha (T1) (206.00q/ha) and single dose of Dimethoate 30% EC @ 200g *a.i.*/ ha (T5) (201.33q/ha). Comparatively low yield was recorded in Cypermethrin 25% EC @ 50 *a.i.*/ ha (T6) (196.33q/ha). The lowest fruit yield was recorded in control (140.67q/ha). T4, Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha was found significantly superior (at 5%) over all other treatments in giving the highest yield.

Table 1: Percent mortality of brinjal shoot and fruit borer at different days after spray (DAS) during Pre and post treatment.

Insecticides	a.i./ha (gm)	Dosage per ha	Pre-treatment population	% mortality of shoot and fruit borer at different days after spray (DAS)										Overall mean
				I Spray					II Spray					
				1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	1 DAS	3 DAS	7 DAS	10 DAS	15 DAS	
Dimethoate 20% + Cypermethrin 3% EC	114.8	650	3.9	67.0 (55.0)	61.9 (53.0)	77.3 (61.7)	75.1 (60.1)	65.3 (53.9)	63.3 (52.7)	67.7 (55.4)	59.5 (50.5)	59.4 (50.4)	34.9 (36.2)	63.14
Dimethoate 20% + Cypermethrin 3% EC	123.6	700	3.6	76.5 (61.1)	73.8 (56.5)	79.6 (63.4)	78.1 (62.2)	70.6 (57.1)	67.4 (55.2)	69.7 (56.6)	68.4 (55.8)	68.5 (55.8)	39.4 (38.9)	69.20
Dimethoate 20% + Cypermethrin 3% EC	132.5	750	3.8	77.4 (61.7)	74.5 (59.7)	81.0 (64.4)	78.7 (62.6)	76.1 (60.7)	68.4 (55.8)	73.5 (59.0)	79.4 (63.1)	79.6 (63.2)	44.8 (42.0)	73.34
Dimethoate 20% + Cypermethrin 3% EC	141.3	800	3.9	88.7 (70.4)	90.4 (69.1)	85.5 (67.7)	81.8 (65.0)	80.1 (63.5)	72.6 (58.4)	79.5 (63.0)	81.5 (64.5)	82.5 (65.3)	55.7 (48.3)	79.83
Dimethoate 30%	200	660	3.9	66.5 (54.7)	59.8 (49.4)	73.7 (59.1)	70.7 (57.2)	48.6 (44.2)	56.6 (48.8)	64.2 (53.3)	57.5 (49.3)	57.8 (49.5)	31.6 (34.2)	58.70
Cypermethrin 25% EC	50	200	3.5	64.7 (53.6)	52.1 (46.4)	61.3 (51.5)	65.0 (53.7)	41.0 (39.8)	49.0 (44.4)	56.2 (48.6)	45.6 (42.4)	45.8 (42.6)	29.4 (32.8)	51.01

Control (Untreated)	-	-	3.7	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0
F-test			NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	sig	Sig	
SEM				1.131	1.076	1.126	1.183	0.48	0.886	1.029	0.841	1.19	0.527	
CD at 5%				3.611	3.435	3.593	3.776	1.533	2.829	3.286	2.683	3.797	1.681	

( ) Figures in parentheses are angular transformed, NS= Non significant, Sig. =Significant

Table 2: Cumulative yield of brinjal (Q/ha) as influenced by different treatments during the experiment

Insecticides	**Dosages per ha**		**Yield of brinjal fruits (q/ha)**	**Increase in yield over control(q/ha)**
	g. *a.i.*/ha	**Formulation ml/ha**		
Dimethoate 20% + Cypermethrin 3% EC	114.8	650	206.00	65.33
Dimethoate 20% + Cypermethrin 3% EC	123.6	700	209.00	68.34
Dimethoate 20% + Cypermethrin 3% EC	132.5	750	216.00	75.34
Dimethoate 20% + Cypermethrin 3% EC	141.3	800	228.00	87.33
Dimethoate 30%	200	660	201.33	60.66
Cypermethrin 25% EC	50	200	196.33	55.66
Control (Untreated)	-	-	140.67	-
F-test	-	-	Sig	-
SEM	-	-	3.218	-
CD at 5%	-	-	10.025	-

Conclusion
It can be concluded from the results that Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha attributed better management over other group of treatments and showed the maximum effect on the shoot and fruit borer when the its spray was done at 15 days interval starting from initiation stage. Thus, resulting in higher yield (228.00 q/ha).

Acknowledgments
The authors are thankful to the Department of Entomology, Indira Gandhi Krishi Vishwavidyalaya, Raipur and also M/S Agro Life Science Corporation for providing the facilities to conduct this research work.

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