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Bio-efficacy of premix 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* 2017-18 and 2018-19. 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 fruit infestation per cent due to shoot and fruit borer, *Leucinodes orbonalis* and also recorded higher marketable yield.

Keywords: Bio-efficacy, brinjal, infestation, *Leucinodes orbonalis*

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 and 2018-19. 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 damage or infestation per cent was recorded one day before spray while post-treatment observation made after 7 and 15 days after spraying, randomly selected five plants from each plot to work out the % reduction of infestation or damage per cent over 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.

Statistical analysis

Observations on brinjal shoot and fruit borer infestation was transformed before statistical analysis. Fruit infestation and yield (q/ha) were worked out with the help of following formula:-

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits (healthy + damaged)}} \times 100$$

$$\text{Percent fruit yield} = \frac{\text{Weight of fruit (kg/plot)}}{\text{Plot area (m2)}} \times 100$$

Results and Discussion

The bio-efficacy of overall mean data on *rabi* 2017-18 & 2018-19 (table-3) revealed that in pretreatment observation, all insecticidal treatments were statistically at par with control there was overall significantly minimum fruit infestation by shoot and fruit borer was observed in (T4) Dimethoate 20% + Cypermethrin 3% EC @ 141.3 g a.i./ha (13.62 % fruit infestation), followed by (T3) Dimethoate 20% + Cypermethrin 3% EC @ 132.5 gm a.i./ha (15.09 % fruit infestation), (T2) Dimethoate 20% + Cypermethrin 3% EC @ 123.6 gm a.i./ha (16.69 % fruit infestation) and (T1) Dimethoate 20% + Cypermethrin 3% EC @ 114.8 gm a.i./ha (17.78 % fruit infestation). Comparatively high fruit infestation per cent (18.79% and 20.49 %) of brinjal shoot and fruit borer was recorded from market sample of Dimethoate 30% EC (T5) and Cypermethrin 25% EC (T6) treated plots, respectively and highest infestation per cent 35.57% was observed in untreated check plots. The efficacy of insecticides against jassids, *Amrasca biguttula biguttula* or leaf hoppers in brinjal has been revealed that (T4) Dimethoate 20% + Cypermethrin 3% EC 141 g a.i/ha caused minimum mean population (4.73 per plant) of jassids followed by (T3) Dimethoate 20% + Cypermethrin 3% EC @ 132.5 gm a.i./ha (5.85 jassids/plant), (T2) Dimethoate 20% + Cypermethrin 3% EC @ 123.6 gm a.i./ha (6.60 jassids/plant) and (T1) Dimethoate 20% + Cypermethrin 3% EC @ 114.8 gm a.i./ha (6.83 jassids/plant). Comparatively high population (7.16 and 8.46 per plant) of jassids has been recorded from Dimethoate 30% EC (T5) and Cypermethrin 25% EC (T6) treated plots, respectively and highest population of jassids, 12.03 per plant was observed in untreated check plots. The efficacy of insecticides against grubs and adults of epilachna beetles, *Henosepilachna vigintioctopunctata* in brinjal has been revealed that (T4) Dimethoate 20% + Cypermethrin 3% EC 141.3 g a.i/ha caused lowest mean population of epilachna beetles (0.49) per plant followed by (T3) Dimethoate 20% + Cypermethrin 3% EC @ 132.5 gm a.i./ha (0.75 per plant), (T2) Dimethoate 20% + Cypermethrin 3% EC @ 123.6 gm a.i./ha (0.77 per plant) and (T1) Dimethoate 20% + Cypermethrin 3% EC @ 114.8 gm a.i./ha (1.15 per plant). Comparatively high population (1.42 and 1.61 per plant) of epilachna beetles has been recorded from Dimethoate 30% EC (T5) and Cypermethrin 25% EC (T6) treated plots, respectively and highest population of epilachna beetles, 2.29 per plant was observed in untreated check plots.

All insecticidal treatments were still statistically better than untreated control. The entire treated plot had statistically highly significant lower population as compared to control. The data of two years mean total healthy brinjal fruit yield of all the treatment was significantly higher over untreated control. The yield of brinjal fruits of different treatments have been revealed that the highest healthy fruit yield (217.00 Q/ha) were registered by Dimethoate 20% + Cypermethrin 3% EC 141.3 g a.i/ha, followed by Dimethoate 20% + Cypermethrin 3% EC @ 132.5 g a.i/ha (205.00 Q/ha), Dimethoate 20% + Cypermethrin 3% EC @ 123.6 g a.i/ha (198.00 Q/ha). The lowest yield was harvested from untreated check plots (136.18 Q/ha) (table-6).

Table 1: Bio-efficacy of Dimethoate 20% + Cypermethrin 3% EC against shoot and fruit borer (*Leucinodes orbonalis*) on brinjal during *rabi* 2017-18.M

S. No.	Insecticides	a.i./ha (gm)	Pretreatment fruit infestation (%)	Post treatment fruit infestation (%)				
				I Spray		II Spray		Overall mean
				7 DAS	15 DAS	7 DAS	15 DAS	
1.	Dimethoate 20% + Cypermethrin 3% EC	114.8	33.59 (36.21)	14.02 (22.29)	24.62 (30.32)	15.12 (23.20)	21.26 (28.02)	18.76 (25.96)
2.	Dimethoate 20% + Cypermethrin 3% EC	123.6	33.62 (36.23)	13.65 (21.90)	22.42 (28.87)	14.37 (22.54)	20.15 (27.20)	17.65 (25.13)
3.	Dimethoate 20% + Cypermethrin 3% EC	132.5	31.86 (35.18)	12.88 (21.26)	19.37 (26.61)	13.56 (21.82)	18.37 (25.87)	16.05 (23.89)
4.	Dimethoate 20% + Cypermethrin 3% EC	141.3	32.32 (35.42)	10.87 (19.31)	17.22 (24.97)	12.17 (20.59)	18.06 (25.60)	14.58 (22.62)
5.	Dimethoate 30% EC	200	31.74 (35.08)	15.65 (23.64)	25.22 (30.80)	15.81 (23.78)	22.32 (28.80)	19.75 (26.76)
6.	Cypermethrin 25% EC	50	32.35 (34.44)	16.28 (24.21)	27.85 (32.54)	17.52 (25.23)	24.16 (30.07)	21.45 (28.01)
7.	Control (Untreated)	-	33.12 (35.92)	33.27 (36.01)	35.08 (37.12)	37.34 (39.08)	39.44 (40.32)	36.28 (38.13)
	SEM		-	1.083	0.887	1.109	0.895	0.994

	CD at 5%	NS	3.24	2.62	3.32	2.65	2.95

( ) Figures in parentheses are arcsine transformed, NS- non significant

Table 2: Bio-efficacy of Dimethoate 20% + Cypermethrin 3% EC against shoot and fruit borer (*Leucinodes orbonalis*) on brinjal during *rabi* 2018-19.

S. No.	Insecticides	a.i./ha (gm)	Pretreatment fruit infestation (%)	Post treatment fruit infestation (%)				
				I Spray		II Spray		Overall mean
				7 DAS	15 DAS	7 DAS	15 DAS	
1.	Dimethoate 20% + Cypermethrin 3% EC	114.8	31.67 (34.23)	12.1 (20.31)	22.6 (28.34)	13.2 (21.22)	19.34 (26.04)	16.81 (23.98)
2.	Dimethoate 20% + Cypermethrin 3% EC	123.6	31.7 (34.25)	11.73 (19.92)	20.5 (26.89)	12.45 (20.56)	18.23 (25.22)	15.73 (23.15)
3.	Dimethoate 20% + Cypermethrin 3% EC	132.5	29.94 (33.16)	10.96 (19.28)	17.45 (24.63)	11.64 (19.84)	16.45 (23.89)	14.13 (21.91)
4.	Dimethoate 20% + Cypermethrin 3% EC	141.3	30.4 (32.44)	8.95 (17.33)	15.3 (22.99)	10.25 (18.61)	16.14 (23.62)	12.66 (20.64)
5.	Dimethoate 30% EC	200	29.82 (33.10)	13.73 (21.66)	23.3 (28.82)	13.89 (21.80)	20.4 (26.82)	17.83 (24.78)
6.	Cypermethrin 25% EC	50	30.43 (32.46)	14.36 (22.23)	25.93 (30.56)	15.6 (23.25)	22.24 (28.09)	19.53 (26.03)
7.	Control (Untreated)	-	31.2 (33.94)	31.35 (34.03)	33.16 (35.14)	36.42 (37.10)	38.52 (38.34)	34.86 (36.15)
	SEM		-	1.103	0.907	1.129	0.915	1.014
	CD at 5%		NS	3.44	2.82	3.52	2.85	3.158

( ) Figures in parentheses are arcsine transformed, NS- non significance

Table 3: Bio-efficacy of Dimethoate 20% + Cypermethrin 3% EC against shoot and fruit borer (*Leucinodes orbonalis*) on brinjal after pre and post treatment pooled data during *Rabi* 2017-18 and 2018-19.

S. No.	Insecticides	a.i./ha (gm)	Pretreatment fruit infestation (%)	Post treatment fruit infestation (%)				
				I Spray		II Spray		Overall mean
				7 DAS	15 DAS	7 DAS	15 DAS	
1.	Dimethoate 20% + Cypermethrin 3% EC	114.8	32.63 (35.22)	13.06 (21.3)	23.61 (29.33)	14.16 (22.21)	20.3 (27.03)	17.78 (24.97)
2.	Dimethoate 20% + Cypermethrin 3% EC	123.6	32.66 (35.24)	12.69 (20.91)	21.46 (27.88)	13.41 (21.55)	19.19 (26.21)	16.69 (24.14)
3.	Dimethoate 20% + Cypermethrin 3% EC	132.5	30.9 (34.17)	11.92 (20.27)	18.41 (25.62)	12.6 (20.83)	17.41 (24.88)	15.09 (22.90)
4.	Dimethoate 20% + Cypermethrin 3% EC	141.3	31.36 (33.93)	9.91 (18.32)	16.26 (23.98)	11.21 (19.6)	17.1 (24.61)	13.62 (21.63)
5.	Dimethoate 30% EC	200	30.78 (34.09)	14.69 (22.65)	24.26 (29.81)	14.85 (22.79)	21.36 (27.81)	18.79 (25.77)
6.	Cypermethrin 25% EC	50	31.39 (33.45)	15.32 (23.22)	26.89(31.55)	16.56 (24.24)	23.2 (29.08)	20.49 (27.02)
7.	Control (Untreated)	-	32.16 (34.93)	32.31 (35.02)	34.12 (36.13)	36.88 (38.09)	38.98 (39.33)	35.57 (37.14)
	SEM		-	1.093	0.897	1.119	0.905	1.00
	CD at 5%		NS	3.34	2.72	3.42	2.75	3.06

( ) Figures in parentheses are arcsine transformed, NS- non significance

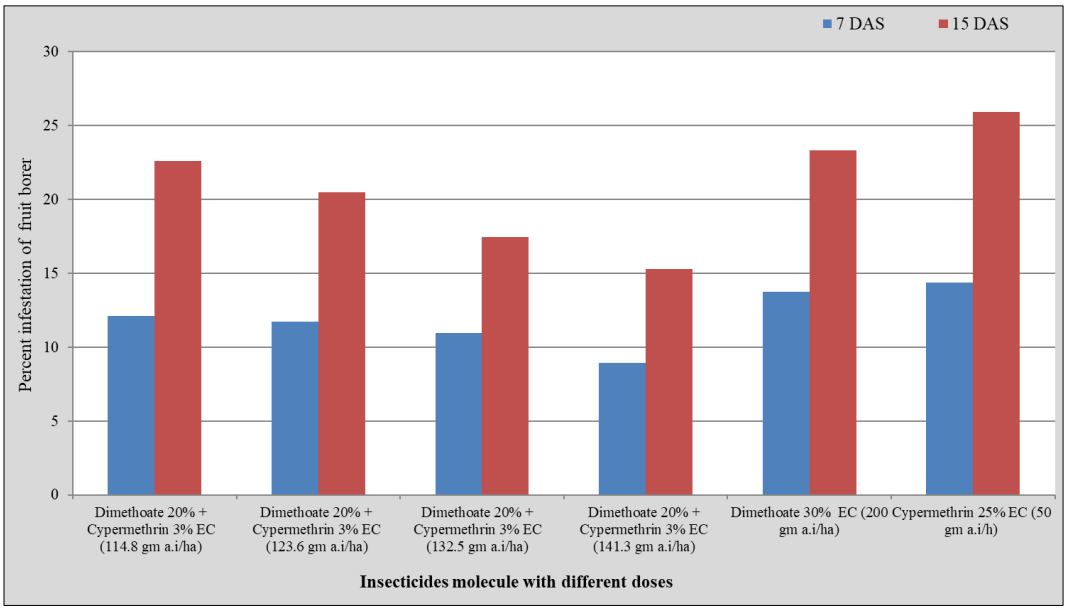

Fig 1: Percent infestation of brinjal shoot and fruit borer at different days after spray (DAS) during 1st spray (pooled data during *Rabi* 2017-18 and 2018-19)

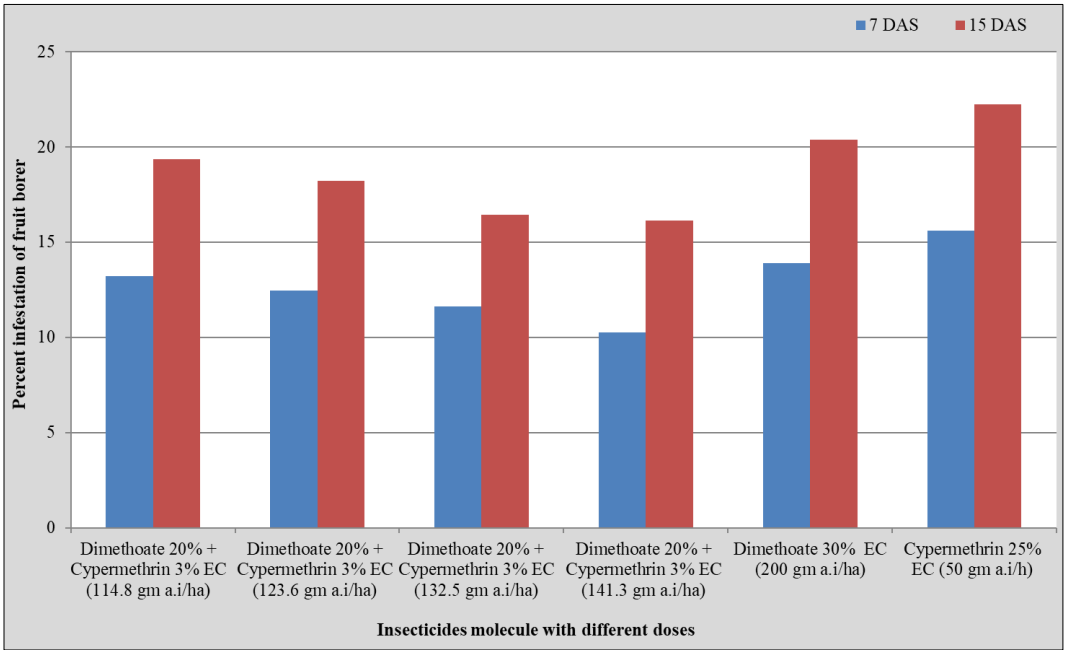

Fig 2: Percent infestation of brinjal shoot and fruit borer at different days after spray (DAS) during 2nd spray (pooled data during *Rabi* 2017-18 and 2018-19)

Table 4: Cumulative yield of brinjal (Q/ha) as influenced by different treatments during the experiment (*rabi* 2017-18)

Insecticides	Dosages per ha		Healthy fruits yield (q/ha)	Increase in yield over control(q/ha)	Cost benefit (C/B) ratio
	gm. *a.i.*/ha	Formulation ml/ha			
Dimethoate 20% + Cypermethrin 3% EC	114.8	650	192.00	57.32	1 : 1.92
Dimethoate 20% + Cypermethrin 3% EC	123.6	700	195.00	60.32	1 : 2.20
Dimethoate 20% + Cypermethrin 3% EC	132.5	750	202.00	67.32	1 : 2.40
Dimethoate 20% + Cypermethrin 3% EC	141.3	800	214.00	79.32	1 : 2.63
Dimethoate 30% EC	200	660	187.35	52.67	1 : 1.66
Cypermethrin 25% EC	50	200	182.35	47.67	1 : 1.59
Control (Untreated)	-	-	134.68	-	-
SEM	-	-	3.314	-	-
CD at 5%	-	-	11.146	-	-

Table 5: Cumulative yield of brinjal (Q/ha) as influenced by different treatments during the experiment (*rabi* 2018-19)

Insecticides	Dosages per ha		Healthy fruits yield (q/ha)	Increase in yield over control(q/ha)	Cost benefit (C/B) ratio
	gm. *a.i.*/ha	Formulation ml/ha			
Dimethoate 20% + Cypermethrin 3% EC	114.8	650	198.00	60.33	1 : 1.96
Dimethoate 20% + Cypermethrin 3% EC	123.6	700	201.00	63.33	1 : 2.24
Dimethoate 20% + Cypermethrin 3% EC	132.5	750	208.00	70.33	1 : 2.44
Dimethoate 20% + Cypermethrin 3% EC	141.3	800	220.00	82.33	1 : 2.67
Dimethoate 30% EC	200	660	193.34	55.67	1 : 1.70
Cypermethrin 25% EC	50	200	188.34	50.67	1 : 1.63
Control (Untreated)	-	-	137.67	-	-
SEM	-	-	3.327	-	-
CD at 5%	-	-	10.126	-	-

Table 6: Cumulative yield of brinjal (Q/ha) as influenced by different treatments during the experiment (pooled data during *rabi* 2017-18 & 2018-19)

Insecticides	Dosages per ha		Healthy fruits yield (q/ha)	Increase in yield over control(q/ha)	Cost benefit (C/B) ratio
	gm. *a.i.*/ha	Formulation ml/ha			
Dimethoate 20% + Cypermethrin 3% EC	114.8	650	195	58.83	1 : 1.94
Dimethoate 20% + Cypermethrin 3% EC	123.6	700	198	61.83	1 : 2.22
Dimethoate 20% + Cypermethrin 3% EC	132.5	750	205	68.83	1 : 2.42
Dimethoate 20% + Cypermethrin 3% EC	141.3	800	217	80.83	1 : 2.65
Dimethoate 30% EC	200	660	190.35	54.17	1 : 1.68
Cypermethrin 25% EC	50	200	185.35	49.17	1 : 1.61
Control (Untreated)	-	-	136.18	-	-
SEM	-	-	3.321	-	-
CD at 5%	-	-	10.636	-	-

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).

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